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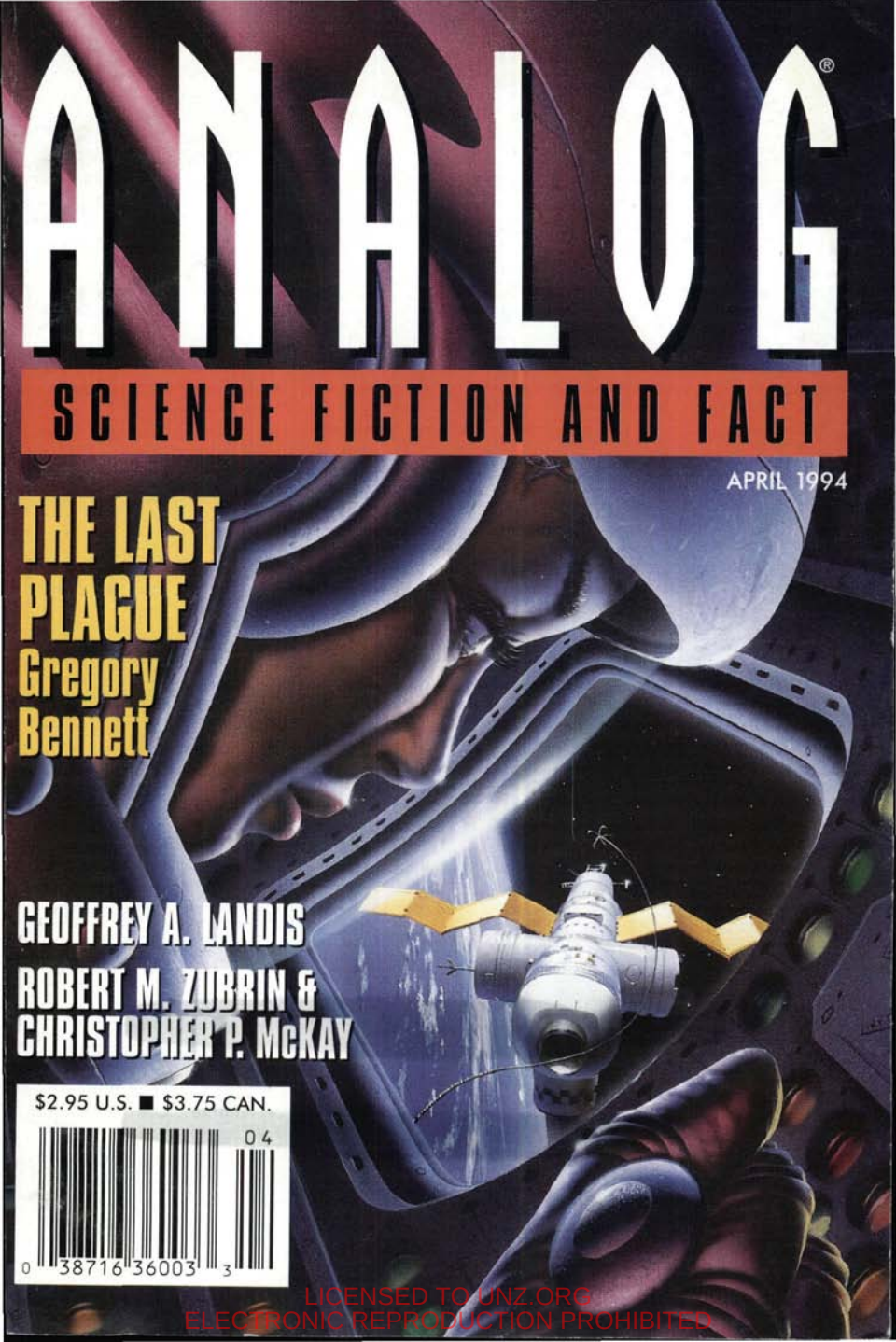

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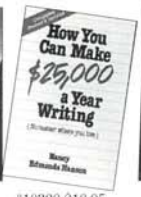

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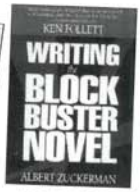

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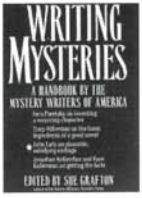

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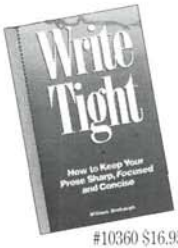

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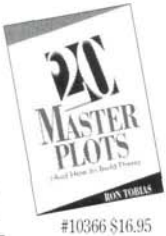

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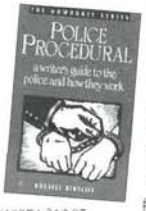

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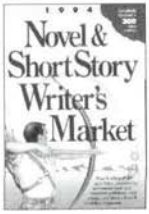

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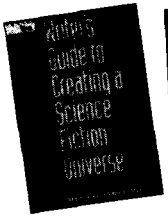

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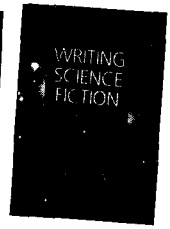

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EDITORIAL Stanley Schmidt

SERVICE CALLS

You might think that reasonable people confronted with the same data would inevitably reach the same conclusion, and thus consensus. A glance at virtually any news story, or a visit to virtually any meeting, will serve as a vivid reminder that it ain't necessarily so.

One possible explanation for the rarity of consensus is that not many people are reasonable. But sometimes that's not the problem. The problem is that it's very difficult for two people actually to *have* exactly the same data—because the data on which a person bases a decision include not only the external facts of the case, but all the personal experience and accumulated values against which he or she weighs those facts.

A case in point of particular interest to most people reading this is what happens every time we have an expensive and frustrating failure of a space probe. The most recent, as I write this, was the abrupt loss of contact with the Mars Observer. A highly publicized earlier instance involved a stuck antenna on Galileo that resisted all efforts to unstick it. Others received less publicity because they involved less money—e.g., a weather satellite costing a mere $67 million instead of the $980 million spent on Mars Observer.

Every time one of these things happens, there is a quite predictable muttering of, "Another billion down the drain! When are they going to get the message and stop throwing money away in space?" The most extreme holders of such sentiments would like to see all space programs shut down as soon as possible, and cite every instance of hardware lost or broken down in space as evidence that space probes are intrinsically wasteful and essentially useless. Why waste money, they ask, on things that we don't really need, that cost a lot of money, and that often fail in places where they can't be fixed?

Others favor continued exploration of space, but see these incidents as arguments against human presence there. You may find it hard to see the chain of logic here, since there *weren't* any humans aboard Mars Observer or Galileo. But that's the point:

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those who interpret the data this way see every failure of a probe as vindication of the wisdom of doing everything with unmanned equipment. After all, if somebody *had* been aboard one of those craft, their very lives might have been endangered! Since equipment often fails aboard spacecraft, if we let people ride them, somebody might get killed. Obviously we can't risk that!

Some claim that equipment failures in space argue not only for putting more of our eggs in unmanned baskets, but in *smaller* unmanned baskets. Shortly after the loss of Mars Observer, John Logsdon, director of the Space Policy Institute at George Washington University, was quoted as saying, "NASA should be doing smaller missions, more rapidly and with more limited objectives. Then if you lose one, you haven't lost everything." True enough; but if you don't lose it, you haven't gained as much as you might have, either.

It seems to me that all of these views miss an essential point and a better conclusion: *all these failures of unmanned probes argue strongly for a human presence in space!* After all, if Mars Observer or Galileo had been carrying a resident repairman, its problem might have been easily fixed and it could have gone on delivering full value on its investment.

The best guess of engineers who worked on Mars Observer is that its problem might have been as simple as a faulty transistor. It would have been a trivial matter for a human passenger to replace it—had a human been present. It would have been similarly simple for a human to unstick a stuck antenna—but nobody was there to do it.

"The problem, according to space experts," according to *Time*, "is that despite elaborate backup systems, space missions have become too complex to be made foolproof." This appraisal underestimates Murphy: *no* system, no matter how simple, can be made completely foolproof. It's true that it's easier to come closer with simpler systems. But even with timid, unambitious, dumbed-down probes there will always be the chance that something is going to go wrong out there—something that a human would have a good chance of fixing, but a dumbed-down probe would not.

"Smaller and simpler" is a questionable way to go in any case. With present methods, it costs so much to launch *anything* into space that a

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prudent researcher—or funding agency—is going to want to get as much return as possible in terms of information per dollar. Electronics can now be made so compact that you can build a *lot* more sophistication into an instrument package with very little increase in payload. It makes good sense to use that capability. It's true that more sophisticated instrument packages mean more things that can go wrong. But that doesn't mean you should be afraid to use them. It means you should be prepared to *fix* things that go wrong.

Unmanned probes to date have had *some* provision for doing that, but not enough. Redundant backup systems are fine, but if the circuitry responsible for switching them in is one of the things that fails, you're out of luck. I'm told that work is being done on small, relatively versatile repair robots to be carried on future missions. Those might be able to repair some of the kinds of problems that have caused past probes to be written off. That's good, as far as it goes—but what if the repair robot fails? What if something else fails in a way the robot has not been programmed to recognize and correct?

In the near future, at least, we cannot expect to have robots that are anywhere near as versatile or adaptable as an intelligent, dexterous, well-trained, and imaginative human being. No matter how many failure modes you anticipate, nature has a nasty habit of finding new ones. For now, at least, only *we* have a good chance of finding unanticipated solu-

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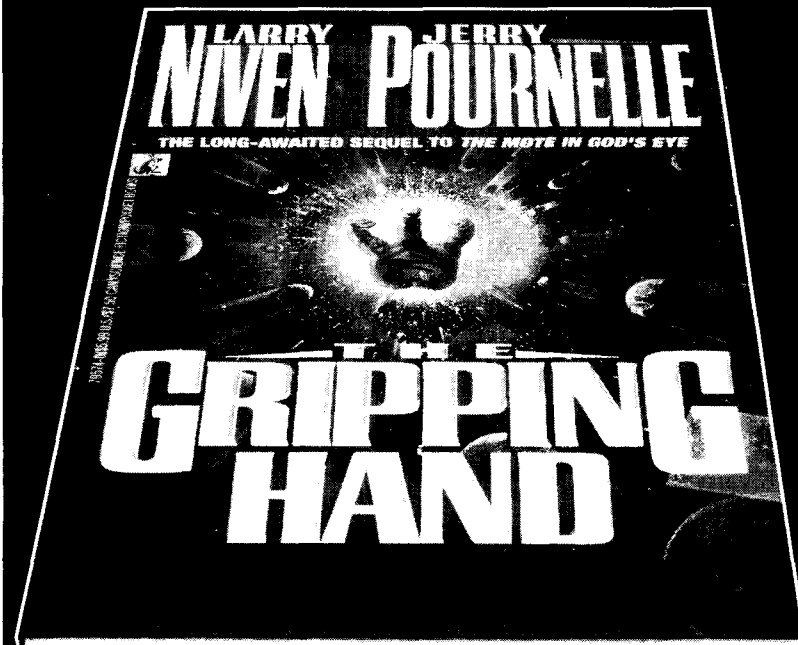
The long-awaited sequel to *The Mote in God's Eye*



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tions for unanticipated problems.

What about the objection that somebody might be killed? Some people understand that risk and are willing to take it. The idea that nobody should ever risk death, even voluntarily, is quite new, strange, and probably not in the best interests of survival of the species. Much of what we have now is built on the efforts of pioneers who knowingly and willingly did things that they could not know were safe, and in many cases knew were dangerous. If all our ancestors had tried to insist on Absolute Safety in everything they did, we would not have the safe and efficient transportation systems we now have, or electricity, or modern medicine, or even heated houses. Ironically, we would probably still be living in caves, with an individual life expectancy that might be as high as 25 years.

Lives have *always* been lost in the opening of new frontiers. In earlier times, that fact was accepted and appreciated. Individuals who were willing to take the risk earned gratitude and admiration as heroes. Now we tell them, "No, you can't do that. You might get hurt."

Maybe our ancestors had a better idea.

There's a job out there that needs to be done. The only well-qualified applicants now available happen to be human. Some of them consider the job so important and so fascinating that they'd jump at the chance to do it. They'd make every effort to get the job done and come back alive, but they know that some of them won't make it. They want to go anyway, and they'd finish the job a lot oftener than machines without their help.

Let's let them.

The idea that human is better is not new; John W. Campbell was pushing it here more than twenty years ago. But it seems to need continuous boosting—perhaps now more than ever, with the current mania for seeking not only to avoid all risks, but to decide for other people which risks *they* should consider worthwhile. ■

Every man takes the limits of his own field of vision for the limits of the world.

Arthur Schopenhauer

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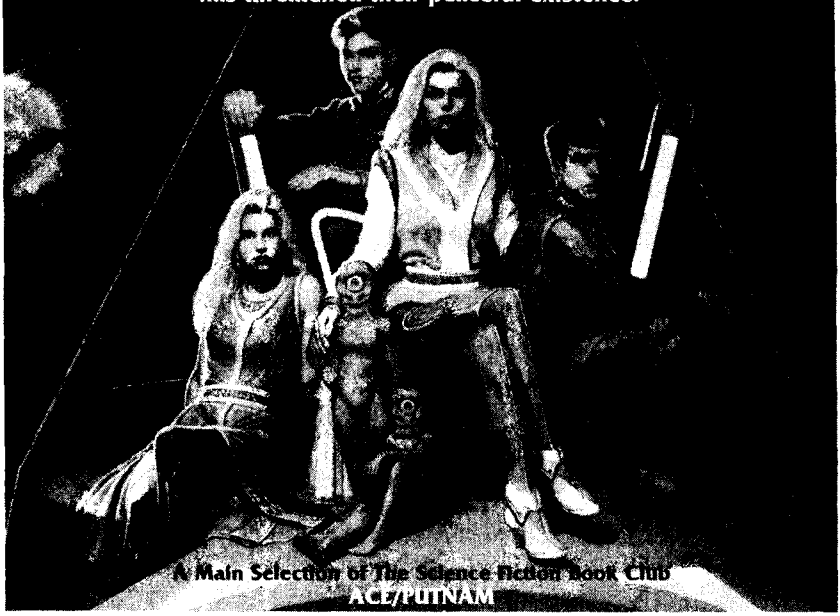

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Some disasters really can threaten whole species—but some species are pretty stubborn.

Illustration by Alan M. Clark

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"It's been more than ten years since I've even kissed a woman," Lloyd whispered. His voice was hoarse, choked with emotion. "I thought I'd never again touch another human being, never make love again." At forty-six, Lloyd Fletcher was still handsome and healthy. His concern did not stem from doubts about his virility.

"That was good," Bailey Tompkins murmured against his neck. "Better than I had ever dreamed. I didn't know it would be so good!"

The first light of dawn breaking through the peaks of the Cascade Mountains imparted a rosy glow to their bedroom. He moved his hands across her back, his fingers trailing down her spine. She relaxed, settling down on top of him with her arms around his neck. A mass of raven curls tickled his nose and cheek. He had no difficulty supporting her; she was a tall woman, but thin, with an impossibly tiny waist that accentuated the flare of her hips. He felt dampness where her face was buried in his shoulder. Tears.

"All you all right?" he asked. She was only half his age, and had been, until a few hours before, a virgin.

She wiped her face on his shoulder and pushed up on her hands to smile at him with startlingly blue eyes. He returned her smile, still wondering as she collapsed back on top of him.

Her breath was warm against his neck. "Oh yes. I get like this when I'm happy. And it's been so long since I've been happy."

They held each other in silence for a while, quietly reveling in their contact. Then she asked, "Do you still love me?"

He stroked her hair, trying to remember the last time he had felt anything so soft.

"I wish I were a poet, so I could tell you how much I love you." He inhaled deeply, relishing the scent of clean sweat mixed with the natural fragrance of her faint human pheromones. *Nobody uses perfume any more: it attract bugs.*

"Will you love me if we meet someone else, other women you could make love with?"

Until death do us part, he wanted to say; but no one ever mentioned death. Death was everywhere. You tried not to see it, never spoke about it.

"I will love you all the days of my life," he said. As quickly as he said it, he realized it was true. He held her tightly against him, and wondered if she were too sore for a repeat performance.

She wasn't.

Finally, Bailey ended the afterglow. "C'mon, sweetie, we have a lot to do! We can't stay in bed all day!" She jumped out of bed, leaving him little choice but to follow.

She was at the front door, starting to zip her face mask against her isolation suit. He intercepted her fingers with his, and kissed her. She responded eagerly, and then held on as if she didn't want to let go.

"It's scary, touching someone," she said. She ran her fingers across his face. "I keep wondering if we'll die now. Have we infected each other?"

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He remembered times, before the plague, when social custom was the only inhibitor to touching someone when he wanted to. "Ozzie was sure we both tested negative. We'll wait two weeks and ask him to test us again if you want."

"But if we tested positive, it would be too late." Her breath filter buzzed in tune with her voice.

"If we keep up with the tests and one of us turns positive, we might know in time to avoid infecting each other," he said. He sealed their inner door. Filtered air flooded the tiny airlock chamber, combining with a pungent insecticide. The mixture condensed into visible vapor when it contacted the cool outside air.

She was silent while the airlock completed its cycle. Outside on the front porch of their chalet, she looked at him and asked, "Then we could never make love again? Never even kiss?"

"Not with bare skin. No."

"I think I would rather die than never make love with you again."

"A lot of people must have felt that way. Billions. My mother and father—"

She laid a sympathetic hand on his arm. "I know. I used to wonder why they did it, but now I understand."

"Me too."

They each pumped up a sprayer and tested the nozzles. She moved closer to him, so that their arms touched as they walked.

Lloyd looked up at their chalet, admiring his own handiwork. The building nestled among towering firs on a hillside high in the northern Cascade Mountains, its high-pitched roof in perfect repair, open shutters and intricate gingerbread woodwork brightly painted to maintain the feeling of a storybook cottage. He wished he could complete the effect with landscaping, but instead of a neatly trimmed lawn and manicured bushes, the chalet was surrounded by a wide, bare rock garden. They circled their home, carefully laying down a widening spiral of insecticide and disinfectant. Despite his misgivings about the poison, he knew it was necessary. One insect bite—from a mosquito, a chigger, a flea, a mite—just one bite from any blood-sucking insect would be all it took for them to acquire the killer virus.

They had repeated this same procedure together each day since Bailey moved into his chalet three months earlier, but this time he felt different about their morning ritual. Before, they had been close friends; now they were lovers, bound in what must pass for marriage in a world almost depopulated of warm-blooded animals. They had become a couple, defending their home from the deadly virus by cloaking its perimeter in a biological desert.

When they finished their chemical warfare against the Cascade's insect population, they loaded their aged four-wheel-drive Chevy Suburban with trout from the high alpine lakes and a load of clothing from Lloyd's elaborate electric sewing machine. The trout were stored in heavy, nitrogen-filled dewars that compressed the old Suburban's springs to their limit. With any luck, the fish would

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test negative. So far, the virus had never been found in fish.

Ozzie's Laboratory and Trading Post was a few miles down U. S. Highway 2, the only surviving business in Gold Bar, Washington. Lloyd could spot Ozzie's place even when they were still high above the town; its fiberglass sheathing sparkled in the morning Sun in stark contrast with the ramshackle abandoned houses and barns around Gold Bar.

He followed Bailey through Ozzie's airlock and obediently observed a posted notice to use the shoe cleaners and to stay on the sticky floormat.

The proprietor's voice boomed from speakers near the door. "Hi Bailey! I see you're taking Lloyd out for a walk again! I'm in the lab. Come on back!" Ozzie's Norwegian accent reminded Lloyd of their host's childhood as the son of a fisherman in Seattle's Ballard district.

They carefully vacuumed off their isolation garments and followed the floormat between rows of meticulously clean stainless steel tables. Their route took them past neatly arranged ranks of pans, lanterns, generators, clothing, foodstuffs in brown paper boxes sealed with plastic, televisions and video recorders, racks of books both rare and common—all the necessities and luxuries of human civilization.

When they met him at his laboratory door, he was still stripping off a second layer of isolation gear. Oswald Gundersen was a huge man whose close-cropped hair and aversion to sunlight had left few wrinkles or gray hairs to reveal his true age. Lloyd thought of Ozzie as older than he, but definitely less than seventy.

Ozzie helped Lloyd manhandle the dewars into his walk-in freezer. "Feels like you got a good haul! Any salmon this time?" His deep voice tended to boom, even through his breath mask.

"No salmon," Lloyd replied. "Trout, and lots of 'em. I didn't have time to get down to the salmon streams. Been too busy sewing."

"S'OK," Ozzie said. "The salmon run's almost over for this year, and we have plenty in stock." With long-handled tongs, he extracted a small pile of solidly frozen fish from the dewars. "We'll let these thaw while we look over the clothes. How ya been feeling?"

"Wonderful!" Bailey said.

"We're doing fine, Ozzie," Lloyd said. "No sniffles, no aches except overworked muscles. How about you?" His question was more than polite social lubricant; one's health had become a deadly serious matter.

"No complaints, but the gods should rethink arthritis," Ozzie said with a broad grin. He held up a one-piece shorts outfit made of see-through nylon and gave a low wolf-whistle. "Say, this is nice! Did you make this, Bailey, or were you the model?"

"The model," she confessed. "I followed your advice, Ozzie. When people can't touch, you have to make sex sexier by giving them more to look at. I thought it would look nice under a transparent isosuit. We have six like that, all different colors."

"How much do you want for 'em?"

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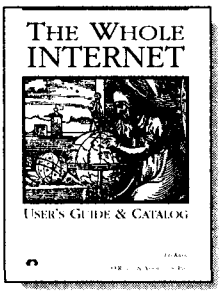

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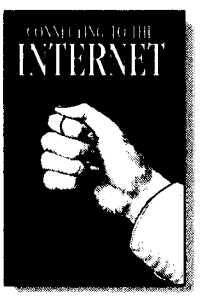

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"We've got about about twelve hours in each one," she said. "What do you think?"

"I can sell them for twice that. How about we split the difference? Say eighteen hours apiece?"

Lloyd felt a twinge of nostalgia for good old dollars, but the monetary system had collapsed long ago when the virus first swept out of Houston. The old paper money was worthless when anyone could walk into a bank and haul away the stuff by the truckload. With no other reliable medium of exchange, the world economy settled on the most precious remaining commodity—hours of human effort. A form of paper money, actually flexible plastic sheets embedded with self-identifying microcircuits, had appeared from an enterprising shop in Calgary. People accepted the new money partly because it would take a counterfeiter longer to duplicate it than it was worth, and partly because it could withstand sterilization. But mostly they accepted it because they had to; there was no other reliable medium of exchange. Money was still scarce, however, so Ozzie filled the need by becoming the only banker within two hundred miles, maintaining the meticulous records of who owed how much to whom.

Ozzie cut a small sample from their fish and dropped it into a test tube along with a few drops of clear fluid. Lloyd felt Bailey's fingers seeking his; she was always nervous when Ozzie assayed the fish. She squeezed his hand and audibly sucked in a deep breath, holding it as they waited for the telltale color change that would indicate the fish had formed antibodies against the virus. This was the most nerve-wracking part of the testing; there was nothing to do but wait.

Two minutes passed, then three; the fluid in the test tube remained clear. Finally, Ozzie announced, "Looks like the fish were healthy when you caught them. If the toxins aren't too high, I can give you full credit for the whole catch."

He clucked over the results from his mass spectrometer and looked up some old data in his log book. With a shake of his head, he made a new notation.

"Where'd you get these trout?"

"Copper Lake, about a mile down Dry Run Creek from our place," Lloyd said. "Why? Something wrong?"

"Nothing serious, but this is the first time I've found toxins in your fish, Lloyd. Have you built the drainage and recovery system around your place, like I told you?"

"Not yet. We just haven't had time." Inwardly, he winced. Getting enough trade goods to be ready for the coming winter took all their daylight hours. There really wasn't enough time.

"Do it. Otherwise, you won't have any trout next year."

"Does that mean you can't buy the fish?" Bailey asked. Her grip on his fingers tightened, her hand trembling. He understood her apprehension; they needed the money for fuel. A wood-burning stove would heat their chalet, but the generator needed diesel.

"Hmm? Oh, no. Uh, I mean, yes! Your fish are still a hundred times

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cleaner than the old FDA standards called for. I'll buy the whole catch! But take care of them. If your runoff starts polluting the watershed up as high as you are, we'll all be out of luck."

When the business was done, Ozzie invited them to visit over a cup of coffee and home-baked sweet rolls in his parlor. He sat at one end of a long table, Lloyd and Bailey at the other. The table was set with separate coffee service for each of them. Ventilators assured that neither party's breath would reach the other without first being sterilized, so they could open their isosuits.

"You've done it, haven't you?" Ozzie asked. Lloyd realized he and Bailey were sitting next to each other in casual disregard of established social custom. From anyone else, he would have thought the question to be inordinately nosey, but in addition to his many other roles in their lives, Ozzie was their doctor and medical advisor.

Lloyd hesitated, so Bailey answered. "Yes, we have. I hope you were right about the tests."

"Don't worry about the tests. You're both free of infection. With just a bit of good fortune, you'll have healthy babies, Bailey!"

She visibly relaxed and reached for a pastry. "You really think so?"

His smile broadened, and then relaxed into a wistful look. "Yes. As long as you're careful, we shouldn't have worse than the normal hazards of pregnancy. It'll be great to have another baby around here! I haven't heard a baby cry since you were too young to know what babies were all about!"

Lloyd took advantage of the fact that Bailey's mouth was stuffed with one of Ozzie's outstanding rolls to inject his own query. "Have you had any luck with the drug?"

Their host's face fell. "No real progress. I've managed to contact a couple other microbiologists on the short wave. We're pretty sure about the source and the vectors for the virus. Nothing new, there. It probably started in Houston and spread through mosquitoes and fleas, but even a sneeze could infect anybody within thirty feet. This is one tough bug! Or, really, a whole family of tough bugs."

"Is there any hope of vaccine?" Lloyd asked.

"Oh, we keep trying lots of things, but no luck so far. I'm trying to come up with a protein that will overwhelm the virus, give it something to latch onto instead of attacking the living cells of the body. It's slow going, and getting slower. There used to be a hundred thousand people working on it, but now I know of only seven besides me. We try to share our data, but describing what we've learned over the radio isn't easy. About all we really know is that it's big for a virus, and it goes into a crystalline state when it's not inside a living cell."

"It's not the AIDS virus, then?"

"Yes and no." Ozzie stared at the silk flowers in the center of the table for a moment, eyes unfocussed. "Let's say it's a close relative. AIDS was tricky; once it got established it mutated faster than the body's defenses

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could keep up with. It was only a matter of time before the AIDS virus threw off a mutant strain that could survive inside a mosquito without killing its host. This version goes dormant when the temperature varies, waiting to awake in the bloodstream of a warm-blooded animal. We've found a dozen strains, each tuned to a different body temperature. But I think they're all closely related, because antibodies found in mice seem to be almost identical to those found in humans. At least they attack the same viruses in laboratory tests."

"Can't you just make a drug from the antibodies?" Lloyd asked.

"Nope. We don't really know what they look like. If we could just grow some protein crystals, we could find out overnight. I'd have a drug in less than a month—not just a preventative vaccine, but a real cure!"

"Anything I can do to help?" Lloyd offered. "You know anything I got, you can have."

"I appreciate the offer. You're a good friend, Lloyd, but the one thing I need won't come from your freehold."

"So, tell us, and we'll go find it," Bailey said. "We've been into Seattle four times already without making a mistake once. We can do it again."

"Thanks, but what I need isn't in Seattle. You won't find it anywhere on Earth—"

"Well, what is it that you need?" Lloyd asked.

"A few days of zero gravity."

Bailey leaned toward Ozzie, her eyes wide with interest. "You mean, like astronauts?"

There had been no space launches of any kind since Bailey was a girl. Ozzie had explained it to them. Space travel required an extensive infrastructure of high technology, but that had vanished along with the population of America's Sun coast. When all effort went into basic human survival, space became a luxury people could no longer afford. Bailey learned everything she knew about astronauts and space probes by watching old videotapes in Lloyd's living room.

Ozzie stared at his coffee pot, brows furrowed. "Yeah, like astronauts. If only we had astronauts again. They had all the equipment I need, up there on the space station."

"But the space station's gone now," Lloyd said.

"Oh, it's still up there. Some of the equipment is still even in good condition!"

"How do you know?"

"I talked to a guy in Colorado last week," Ozzie said. "He's managed to get some of the encryption boxes they used for the radio link to the space station, and he's actually talking to it with a big tracking antenna that once communicated with spy satellites. Said his father, the gods rest him, used to work for NORAD. Anyhow, once every few days his antenna can see the station and talk to it. The laboratories have leaked down to zero pressure, but the station's still generating electricity, keeping itself warm! It even reboosted itself a couple years ago, went into a really high orbit. It can't do that again; used all its fuel to get up there. Kinda weird, though." His voice trailed off.

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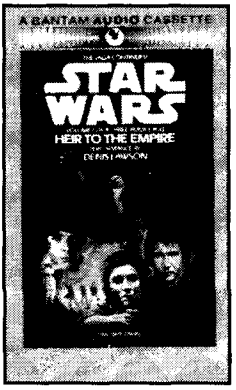

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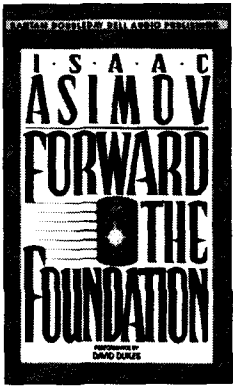

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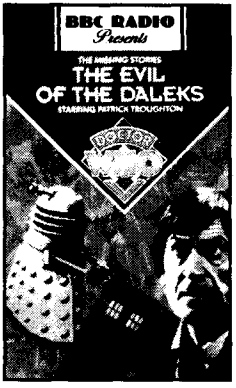

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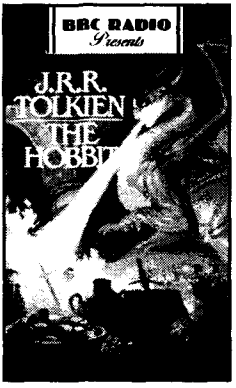

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"Weird?" Bailey prompted.

"Yeah, weird. This guy says the space station is lonely. It likes to have somebody to talk to. It keeps inviting him to come up for a visit."

"Maybe the guy in Colorado can just ask the space station to grow your crystals," Bailey said.

"Nope, won't work. The station doesn't have any robots inside to manipulate the samples, and it doesn't have the right samples to work with. Besides, there's no way a robot could do the work. It takes too much fine manipulation and on-the-spot judgment. Sometimes, you just gotta have human hands to get the job done."

"You need the crystals to make the drug?" Lloyd asked.

"Not the drug, no. We need protein crystals to show the molecular structure of the virus, how its atoms are arranged. The geometry of the virus's molecules shows up in the structure of the crystal itself, only on a bigger scale. I can use x-ray diffraction to make a picture of the interior structure of the crystal."

"You got stuff you need for x-ray diffraction?"

"All the necessary equipment is up there on the space station," Ozzie said, "but there's no way to get there."

"Yeah, no way to get there."

"Then there's no hope for our children?" Bailey asked. Her eyes were downcast, staring at her coffee cup. Lloyd watched dew gather in those enormous blue eyes and wished he had never led them into this conversation.

Ozzie's eyes returned to their examination of the coffee pot. "Not much of one without knowing the structure of the virus. We don't even have enough experimental animals left to test candidate drugs on. Forgive me for raising false hopes."

They sat in silence for a while, sipping their coffee until it was gone. Lloyd welcomed the opportunity to push unpleasant thoughts about the future to the back of his mind and get back to the day's business. They used up most of their credit on staples, diesel fuel, gasoline, gunpowder, and ingots of lead for casting bullets. Ozzie had acquired several bolts of fabric which he gave them on consignment against future contributions to his clothing sack. He followed them to his front door, where they bid their respects to their host.

While Lloyd was checking the seals around the Suburban's doors, Bailey suggested, "Why don't we visit Wayne while we're in town? We haven't looked in on him in weeks."

"But you always get depressed when we see Wayne."

"Yes, I know," she said, "but I get even more depressed if we don't stop by. I guess I feel guilty either way."

The Suburban rocked like a boat in heavy water, sliding around on smooth fist-sized gravel which paved a path among Douglas firs to Wayne Braun's cottage. Lloyd counted nineteen warnings affixed to tree trunks and sign posts along the road, each bearing the trefoil omega symbol and one ominous word—PLAGUE. A particularly deep rut jerked the steering wheel. When he grabbed the wheel

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to steady the Suburban, he realized he had been unconsciously driving with one hand, and checking the seals on his isosuit with the other.

The nineteenth warning sign was nailed to Wayne's front door. His small cottage glistened where stray sunbeams filtered through surrounding forest giants.

Wayne looked up from beneath the hood of his Bronco and waved merrily as the Suburban crunched to a stop in his driveway. Bailey was out of the Suburban, running toward him even before Lloyd had shut off his engine. Wayne grabbed a dirty towel and managed to take a few futile swipes at the grease on his isosuit before she collided with him. With a hearty whoop, he lifted his half-sister up by her arms and spun her around.

He looks thinner, but he still has his strength, Lloyd thought. *How much longer? Three years? Four?*

"I got the Comanche running again yesterday," Wayne said. He carried three cans of beer into his everything room and set them on the coffee table. "It was good to be flying again. I went up through Deception Pass and down around Richland before I came home. Hardly anybody on the highway out there, just a couple of trucks."

Lloyd snapped a filter onto one of the beers and pushed its straw through a seal in his isosuit. He settled back on Wayne's sofa and put his arm around Bailey, gently stroking her shoulder.

"I expect folks are too busy just trying to keep their lives together," Lloyd replied. "They don't have time to travel."

"No place to go anyway," Wayne said. "You're not drinking, sis?"

"Not today, thanks Wayne." She was grinning through her face mask. "I might be pregnant!"

"Well I'll be—I thought I saw a change in you two, but I wasn't going to say anything. Congratulations! Both of you!" He raised his beer. "A toast! To the child!"

Lloyd raised his own drink and took a sip through the long straw.

"Sorry I can't offer you a soft drink, baby sister."

"Thanks, Wayne, but it may be premature. We only just, uh—" She grinned again, "—started this project yesterday."

"Even that calls for a toast!" Wayne said, but his exuberance quickly faded. "Too few people are even trying any more. You two are an inspiration to me. I have to know people will keep trying. Someday, people will beat this thing!"

"We will, Wayne," Lloyd said. "Don't give up hope. Ozzie is still working on it."

"Yeah, but Ozzie is almost alone in his work now. It'll be blind luck if he ever does come up with something."

"He thinks he could find a cure if he could grow protein crystals in zero gravity," Bailey said.

"Meaning he needs a space station," Wayne said. "Well, we have one of those, but no way to get there. If only there had been time for the Delta Clipper to get flying. Damn unions!"

Lloyd opened his mouth to reply,

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but said nothing. He didn't want to remind his new brother-in-law that he had been a member of the very same union which had held the single-stage-to-orbit vehicle for ransom. He decided to steer the conversation away from that subject.

"How about missiles?" Bailey's brother was a pilot, just graduated from navy fighter school when the plague hit. But that was closer to being a rocket scientist than anyone else they knew. "After all, the first men we ever sent into space went up on top of missiles!"

Wayne looked at him quizzically. "You might be on to something there, Lloyd. Maybe all Ozzie needs is one guy up there to do his dirty work! Let's call him!"

"You have the phone working again?" Bailey asked.

"Yep, since last week. Full video. Ozzie and I ripped down a few miles of television cable and started rewiring Gold Bar."

Hubert Edison's voice crackled from the short-wave radio. Ozzie tweaked a few knobs, but the reception didn't improve much. Despite the interference, Lloyd was enjoying his talk with the boy. It felt good to experience the world beyond the Columbia River, even if only by voice. When the long-distance phone lines went out for the last time, ham radio became the only means of cross country communication, and Ozzie had the best ham rig in Gold Bar.

For the past week, Hubert had been driving all over Colorado Springs, recruiting erstwhile Air Force engineers for this one meeting.

"They don't think it will work," Hubert said. He was relaying the Colorado Springs end of the conversation. There was a pause. Then, "We might be able to get a guy up there with the equipment you need, but he'd never make it back. We'd have to choose between a heat shield and landing rockets. They're not sure they could lift either one; there's definitely no way to lift both."

Lloyd could almost picture the retired missileers crowded into Hubert's radio shack, frantically fingering their pocket computers every time he asked a question.

"How about parachutes and a water recovery, like *Apollo*?" he suggested. "Then we wouldn't need landing rockets."

Hubert's response was not encouraging. "Think of the *Mercury* capsules, not *Apollo*. We don't have a Saturn rocket. Even with a water recovery, they used a landing bag to absorb the impact. Besides, they had the entire U.S. Navy to search for their space capsules, and better guidance than we can hope for. Our spacecraft could be hundreds, maybe thousands, of miles off target. We'd have to bring the astronaut down on land, where he can survive until we find him."

"Doesn't matter," Lloyd said. "We have a volunteer, even if it's a one-way trip."

He waited through a long pause. Seconds passed, then minutes. He was beginning to wonder if they had lost contact when Hubert finally came back.

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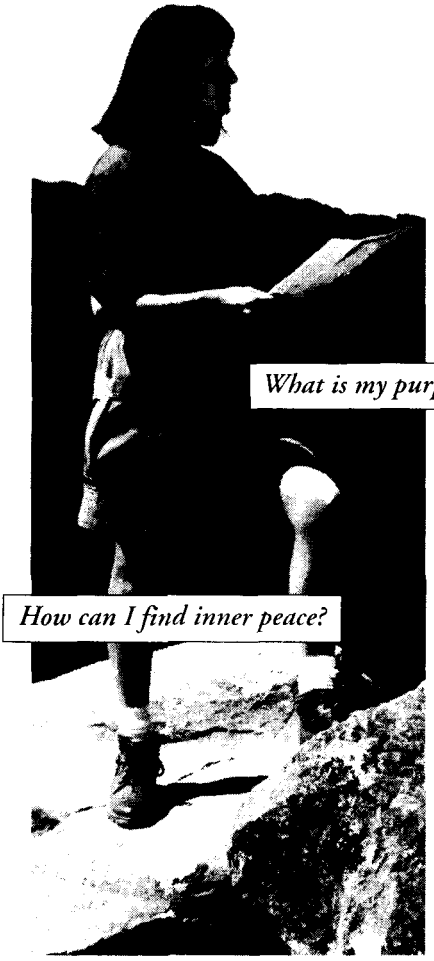

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"They want to do it!" Lloyd could detect the boy's spirit of triumph even through the distorted radio transmission. There must have been quite an argument at the other end. "We'll meet you in Texas in three months!"

Bailey rode shotgun with Lloyd in the lead truck, while Wayne and Ozzie followed behind in two more trucks. He regretted they had not simply settled for four-wheel-drive utility vehicles, but Ozzie had insisted on eighteen-wheeler Kenworths. The big trucks were roomy enough to be both transport and home to them; each trailer had a little apartment built into a sealed section outfitted with air-conditioning equipment from Ozzie's stock.

Their convoy rolled over long-neglected highways overgrown with weeds. With dynamite and chain saws and the sheer power of their enormous trucks, they moved wrecked vehicles and fallen trees from their path, but bridges were a different matter. Even a tiny culvert could send them hours out of their way. They encountered their worst problem with bridges in Utah.

BRIDGE OUT
DETOUR AT GREEN RIVER

They were in hilly scrub land, headed east on Interstate 70. The hand-lettered warning was on a barn door propped up against an outcropping of rock at the edge of the road.

"Better slow down," Bailey suggested. She was curled up on the passenger's seat, wearing a new style of her own invention, almost nothing beneath a clinging, transparent isosuit. Lloyd was irritated that this new problem distracted him from enjoying the view both outside and inside the cab of his truck.

"Yeah," he agreed, though he had been leading the convoy at less than forty miles per hour on the twisting highway. "That sign looks new. Someone must still live around here."

He keyed his CB microphone. "Ozzie? Anything on the radios?"

"Not a soul." Ozzie's normally pleasant voice came across the airwaves as an unpleasant squawk. "Nobody on CB, FM, or short wave."

Wayne broke into the conversation. "Me neither, but I noticed that sign, too."

"Well, let's take it easy and keep our eyes open," Lloyd said. "We might have to find a local to tell us how to get across the Green River." He drove on past another hand-lettered sign directing them to take an overpass northward toward the detour route. "I want to see what happened to the bridge," he said.

"OK with me," Wayne agreed, "but make sure we've got room to back and fill if we have to. There's not much room to maneuver here."

Two miles later, they rounded a hill on a steeply descending grade and saw the bridges. Two new spans of concrete crossed high above the river, but the east-bound bridge ended in a confused mess of twisted reinforcing bar. Lloyd eased onto the shoulder well short of the bridge. In his mirrors, he saw Ozzie turn off several yards behind him. Wayne must

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have pulled off out of sight around the bend.

He started to get out, but Bailey called him back. "Hey! Wait for me!" She hastily pulled on one of his bulky sweaters over her isosuit and grabbed her shotgun. "I think our truck-stop rules should apply here," she explained.

He couldn't argue with her logic, especially since he had made the same speech to her back in Millwood, Washington. He shouldered his M-16 rifle and clipped a portable radio to his belt before meeting her in front of the truck.

Ozzie and Wayne joined them near the ragged edge of the bridge. Lloyd saw they were similarly armed.

Wayne pointed. "Looks like we could get across over there."

Lloyd followed Wayne's finger and inspected the westbound bridge. It looked good as new, albeit dirty and unused. He eyed the ravine separating the east and west highway lanes.

"We'll have to go all the way back to that overpass," he said. "I didn't see any other way to get across. But I wonder why this bridge fell down and the other one didn't? I'd think an earthquake would have knocked them both down at the same time."

"It was no earthquake," Wayne said. "Look here." He knelt down right at the precipitous edge. "See these round furrows?"

"Yeah. So what?"

"Drill holes, for explosives. Probably dynamite."

"Uh oh—" Bailey said. Her eyes quickly shifted from Lloyd to her shotgun.

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"Let's get back to the trucks," Ozzie suggested.

They moved as a group, staying close to the blasted rock wall that lined the south side of the highway. The lead truck was just as they had left it, cab doors still open. As they neared Ozzie's rig, they heard the low thunder of a giant Kenworth's engine spooling up.

Lloyd rounded the curve in the road right behind Wayne, just in time to see Wayne's truck backing away from them. There were two men in the cab; both were apparently concentrating on the rearview mirrors.

Wayne yelled invectives at the hijackers and fired his rifle into the air as he ran after the slowly moving truck. When the truck started to angle across the highway, Lloyd assumed they were maneuvering to turn around. He shouted triumphantly; this would give them time to catch up. He immediately learned how wrong his assumption was.

The big Kenworth kept accelerating in reverse as it moved into the driving lane, revealing a Toyota Land Cruiser parked behind it on the shoulder. Three men stood by the Toyota, each with a long-barrelled weapon already shouldered. A fourth man was in the driver's seat. Lloyd could see the patches in their isosuits even from fifty yards away.

Suddenly Wayne jumped convulsively to one side, and a scant moment later the sound of a single shot split the air. Lloyd dropped to the ground, landing hard on elbows and knees. Wayne fell and rolled into the gully between the highway shoulder and a sheer cliff, leaving a ruddy cloud where he had been standing.

Lloyd was completely exposed where he lay on the road; there was nothing to do but return fire. Blessing the practice he'd had with the M-16, he flipped the gun to full automatic and sprayed his entire clip toward the Toyota. Even when his gun stopped firing, he could still hear shots coming from behind him, the chatter of Ozzie's automatic weapon and the boom of Bailey's shotgun. Without taking time to see if their enemy had ducked to avoid the covering fire; he rolled into the gully a few yards from Wayne.

Suddenly, all was quiet save the distant whining of the Kenworth's reverse gear. Both Ozzie and Bailey must have emptied their guns. While he fumbled in his shirt pocket for his extra clip, he chanced a peek. The Toyota was still there. Three men were down, lying in a pool of bloody radiator fluid. The Land Cruiser was a mess—shattered windshield, no headlights, its grille and fenders riddled with punctures.

Keeping an eye on the Toyota, he crawled across the gravel to Wayne.

"Wayne, you still with us?" It was inane, but he couldn't think of anything else to say.

"M'OK," Wayne mumbled, but he clearly wasn't. Blood was spraying profusely from his right thigh. The bullet had hit a few inches below the hip. A tell-tale puncture in his isosuit showed where the bullet had entered. There was no exit wound.

Bailey crawled up to them. She was subdued in fawning over her

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wounded half-brother, her eyes distracted toward the enemy vehicle.

"No movement out there," Lloyd said. "Looks like they're done for. Do we go after the truck?"

"Let it go. We have to get Wayne inside," Ozzie said. "His isosuit is punctured. The tiniest infection will kill him!"

Bailey was the only one wearing clothing outside her isosuit, so Lloyd's favorite sweater became a temporary pressure bandage against the wound. He was reluctant to leave her outside while he helped Ozzie get Wayne into the truck, but this was a time when her brother's life depended on sheer strength. When they had the patient restrained on Ozzie's cot, he returned to stand guard with her.

They kept low, crawling along the gully toward the Land Cruiser. Nothing moved near the vehicle, inside or out. Three men still lay on the pavement near their guns.

"Scope-sighted hunting rifles," he whispered. "Good for moose hunting, back when there were moose, but not very effective in a close-range fire fight." He pointed to a whip antenna mounted on the Land Cruiser's bumper. "They must have been listening to us on the radio." He was surprised that Bailey even knew the language she used to compose an epitaph for the would-be hijackers.

He moved farther down the gully so he could sneak up on the vehicle from behind. From the gully, Bailey trained her shotgun on the car door. A quick scramble brought him to the side of the Toyota. Instead of putting his head up, he reached with nervous fingers for the door handle and quickly snatched it open.

An almost headless corpse fell out. It was messier than he had expected, but he had been prepared for something like it.

Not so, Bailey. He heard gagging behind him and spun around. She was on her hands and knees by the side of the road. Throwing up in one's isosuit is a messy affair, but usually not particularly dangerous. Lloyd had done it once, on a sorrowful night long ago when he tried to use alcohol to drown the misery of cremating his parents.

This time, though, Bailey had little clothing beneath her isosuit to protect her. She stood up and started to walk clumsily toward him, and screamed. When her isosuit touched her body, her own stomach acid contacted her unprotected skin. She reflexively put her hands to her breasts to protect them, and made it even worse. When she looked at him, it was with the wide eyes of a confused, wounded animal.

This was no time to be polite. "Get to the truck!" he ordered. "Out of your suit! Wash! Baking soda! Now *run!*"

She ran, tugging at her isosuit to keep it away from her body.

Lloyd found himself alone, with only the dead for company. He tried to look every direction at once, wondering if the hijackers had compatriots who even then were settling their sights on the back of his head. He scanned the terrain. Theoretical enemies would find no cover on the high

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cliff beside the road, so he only had to watch for someone approaching along the highway or across the ravine between the east and west lanes. He held his breath and listened, expecting that any moment the crack of gunfire would disturb the rustle of light wind against his isosuit and the low murmur of the idling trucks. When he was finally satisfied that no attack was soon forthcoming, he decided it was safe to use his walkie-talkie and reported to Ozzie what they had found.

"We have a problem here," Ozzie said. "Wayne has lost a lot of blood. He's in shock now. I'm afraid we'll lose him if we can't replace the blood."

"All right," Lloyd replied. "I'll be right there with my sleeve rolled up."

"Thanks, but it wouldn't be enough, even if you had the right blood type. He's going to need at least six units before this is over, maybe more. There's no point in killing you both."

"Would plasma do?"

"Sure, if we had enough. I have the centrifuge to separate it out, but I couldn't safely take more than two units from you. And I'm not so sure about putting your platelets back in any case."

Lloyd cast his eyes upon the mortal remains of the roadside entrepreneurs. He didn't know what microbes they carried, but Wayne already had the plague. That was little comfort; almost any other disease would kill him. No matter, there wasn't anything else to do.

"I wasn't thinking of me," he said.

* * *

Lloyd was feeling positively ghoulish by the time the job was done. With a sigh of relief, he climbed into the cab of his Kenworth and called Bailey through the intercom.

"You all right back there?"

"I'm fine, but I'm still trying to get the stink out of my isosuit. Want me to put on my other one and come up?"

"No, just get comfortable. We want to get the trucks turned around before it gets dark so we can put some miles between us and this place."

"Fine with me! Any more problems out there? How's Wayne doing?"

"Ozzie says he's stable enough to be left alone for a little while, but he locked his intercom open, in case Wayne wakes up. Hang on! Brake release!" Perhaps it was only an accident that his bumper clipped the Land Cruiser as he passed, but he thought the Toyota made a delightful crunch when it hit the sheer cliff face at the side of the road.

They backtracked to the overpass and crept across the Green River going the wrong way in the left lane. The marked detour probably would lead them to the bandits' compatriots, so he avoided it. He tried to dismiss the loss of Wayne's truck from his mind. Somewhere they would find replacements for the radar and avionics gear, and even Wayne's Bronco was not irreplaceable. But it was hard not to regret losing the airplane that had been Wayne's pride and joy for so long.

He pushed on even after dark before deciding to bring their dimin-

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ished convoy to a stop for the night well past Grand Junction, Colorado. There were still a lot of survivalists in the mountains, so he wanted to get high enough in the Rockies that it would be unlikely they would encounter any permanent residents.

A short side road to a scenic viewpoint provided plenty of room to turn the trucks. They circled to point toward the road and finally shut down the diesels.

Ozzie met him beside his truck. "We'd better set up a watch," he advised.

"We never have before."

"We've been stupid," Ozzie said. "Want me to take first watch?"

"No, you go check on Wayne and get some sleep. I'll stay up." Lloyd bid Ozzie a good night and checked in with Bailey before setting up his watch in the cab of his truck.

An eerie quiet enveloped him when he turned off all the exterior light. There was no Moon, but as his eyes adjusted to the darkness he saw the landscape surrounding him. Everything had a ghostly blue cast in the faint illumination of starlight. Not even the sigh of their electric generators could compete with the stillness of the high mountains. There was no wind, no animal sounds, not even the whine of flying insects. Perhaps, without warm-blooded animals to feed on, even mosquitoes were dying out. One could hope.

Once he got used to it, he welcomed the peaceful ambience; it reminded him of his home in the Cascades. Had it been just that afternoon they fought and killed a band of hijackers? Or had it been a decade ago?

Ozzie's footsteps were almost jarring when his friend approached to relieve him at the watch.

Bailey must have anticipated his mood. When he had disinfected himself and cycled through their airlock, he found she had the lights dimmed very low. The one-room apartment they had built at the front of their trailer was tiny, but comfortable. Lloyd's love for fine craftsmanship showed in everything: the solid wood paneling, the intricately handwrought cabinets and furniture, even the oversized bed. Especially the bed. And especially the occupant.

Despite the dim light, he could see some redness where her skin had encountered the acid. "Feeling better?" he asked.

"Much. It's still sensitive. Not painful. Just—sensitive. And a little dry, after all that washing."

"Did you use baking soda to neutralize the acid?"

"Yes. It worked wonderfully."

"How about skin lotion, to relieve the dryness?"

"I was hoping you would do that," she cooed. She handed him a plastic bottle.

Lloyd carefully warmed some of the lotion between his hands, and happily surrendered to the inevitable.

Nobody was home in Denver, but they found a small hospital in Strasburg, Colorado where they could X-ray Wayne's leg. Ozzie's suspicions were confirmed; the bullet had shattered the bone. A few years before, the situation would have called for

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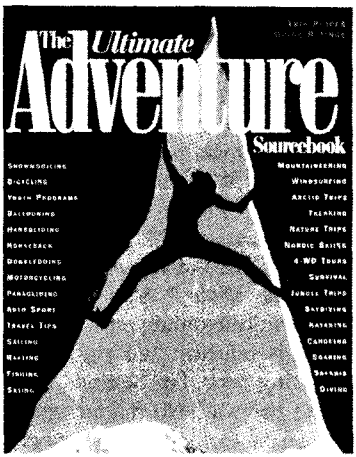

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orthopedic surgery, but there were no surgeons to be found. They set the fracture as well as they could and hoped for the best.

Bailey had missed her second period by the time their convoy crossed into Kansas. On their way south, they diverted to a ghost town which once had been the city of Independence. Ozzie raided the dusty maternity wing at Mercy Hospital for obstetrics equipment. When he was done, the back of Lloyd's trailer was filled with gear for welcoming babies into the world—birthing chair, self-contained intensive care unit for infants, even diapers and bottles.

They convened in Ozzie's parlor on their first night in Texas. Wayne lay on a cot, propped up with pillows. His hips and right leg were encased in a polymer cast. Lloyd and Bailey shared Ozzie's easy chair, while Ozzie made do with a packing box and the wall of his trailer for a backrest.

"You're still thinking of doing it?" Lloyd asked. He tried to hide his surprise.

"More than ever!" Wayne said. He was adamant. "I'll never fly an airplane again, but I won't need my legs to fly the spacecraft. This could be my only chance to do something important before I die. As long as Ozzie says I'm up to it, I'm going!"

"You should be able to do it as well as anyone could," Ozzie said. "Your leg will heal as much as it's going to by the time we're ready to launch someone."

"But it's suicide, Wayne!" Bailey jumped off Lloyd's lap and knelt next to her half-brother. Gently, she stroked his head through his isosuit. "I don't want you to die up there."

"Neither do I, sis. I don't want to die down here, either, but I will. The cards are dealt; it's up to me how I play the hand. I know it's a one-way trip, but it's the only thing I can do to fight this thing. I just can't let someone else take my place on the outside chance we'll get a cure in time. And if we did find a cure, I'd have to live on knowing a healthy person died in my place."

Bailey looked distraught. Her eyes searched out Lloyd's, pleading.

"I don't know what else to do," Lloyd said. He wished she hadn't turned to him. He felt like he was the court of last resort, condemning the last surviving member of Bailey's family to death. "We can't spare Ozzie, and I'm a machinist, not a pilot. And you know how I feel about the idea of you going."

"Yeah," she agreed. "Maybe I could learn it all in time, but I have another life to think about." She hugged Wayne, carefully avoiding putting any stress on his injuries. "All right. I'll stop sniveling now. I'm behind you, Wayne, all the way. No matter who they bring from Colorado, I'll support you to be the astronaut."

Wayne smiled and pulled her close, kissed her as best he could through two layers of isosuit. "Thanks, baby sister," he said.

West Texas was baking under the late-August Sun when they reached the missile range. The Colorado team had apparently arrived long before

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them and started to set up a camp in the desert. Lloyd wasn't sure the open sand would support the weight of the trucks, so he stopped at the end of the pavement, a few hundred yards short of the others.

As soon as he stopped, Bailey scampered out of the truck. As she merrily jogged straight toward a stockade formed of large trucks and recreational vehicles, she faded into a surreal landscape born of heat waves and monochrome beige scenery. Lloyd watched her run, and chuckled to himself. She was wearing one of her most abbreviated outfits beneath a transparent isosuit. If there were any prudes among the Colorado team, they'd have to get used to Bailey right from the start!

He worried momentarily about her madcap dash through the sage and tumbleweeds, but dropped the thought. There were no warm-blooded animals left in the Texas desert, so rattlesnakes had died off with their prey.

While he and Ozzie were helping Wayne hobble out the truck, Bailey emerged from the heat, towing a tall, gangly redheaded kid by his hand.

"Look who I found! It's Hubert!" she called.

Hubert Edison turned out to be younger than his voice. Based on a trace of acne and the lad's eager but uneasy manner in dealing with adults, Lloyd placed him at seventeen, plus or minus one year. One glance at Hubert told him an important fact about the Colorado Springs team—they were *equipped*. Except for his wide face mask, Hubert's isosuit was opaque white, a good choice for dealing with the searing heat of the desert, and it was brand new!

From the cab of Lloyd's truck, Hubert directed them along an oiled path to their designated parking sites. The Colorado team had arrived three weeks before, and they hadn't wasted the time. The camp was sited around a missile control complex. A newly sealed wood-frame structure, the entrance to several subterranean launch control facilities, now served as the main office.

Echoing the background of most of the Colorado team, the camp was laid out with Air Force precision. Vehicles and pressurized tents formed a rectangular array aligned with the points of the compass: living quarters, construction equipment, laboratories and workshops, supply depot, each in its assigned plot. Thinking back on their long trip down from Gold Bar, Lloyd felt comforted by the appalling arsenal of weapons spread throughout their camp.

The metal-bending equipment in the machine shop made his mouth water; they had joined four huge trailers together to house it all. Behind the shop, ranks of generators puttered in the background.

At first he was puzzled by the repetition of function among the machines, but as Hubert led them around, making introductions and cataloging the expertise of each member of the team, he began to understand. Among the scientists, engineers, pilots, shopkeepers, soldiers, and missileers now in camp, there was only one machinist—him. The

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Colorado team had simply loaded their trucks with every bit of equipment that looked useful.

Bailey snuggled close to Lloyd while Hubert showed off the frozen food in the refrigerator trailer. Her attire was not suited to the cold, to be sure, but more than that she seemed to need reassuring closeness as they viewed the exotic foodstuffs. She had never tasted beef, had never even seen a live cow. Under Ozzie's exacting inquiries, Hubert explained what he knew about how people in Colorado Springs raised warm-blooded animals in environmentally controlled buildings. Caring for the animals in an enclosed environment was abominably expensive, but there was never meat enough to satisfy the demand.

They followed Hubert to a motor home parked beneath a towering dish antenna. Only the back half was his home; the space in front was filled with radio gear. Ozzie cooed and clucked over the extent of Hubert's equipment—everything from simple CB radios to cryptographic units and a satellite transceiver. A small computer ran continuously, calculating the space station's ground track and predicting opportunities for contacting the orbiting laboratory.

Lloyd eagerly accepted Hubert's offer of a Colorado-style dinner, but he noticed Bailey left a lot of food on her plate. Red meat was just too strange for her. However, Hubert saved the day with dessert; she obviously relished her first experience with ice cream.

They joined the rest of the camp in the meeting hall after dinner and met Colonel Masters for the first time. Lloyd was surprised, not so much by her sex, but by her age. Colonel Christie Masters reminded him of Ozzie; her years showed only in her short bob of snow-white hair and the mature shape of her nose and jawline. And like Ozzie, the wizened, patient look in her large eyes spoke of eons rather than years.

After introducing the newcomers, Christie Masters briefed the assembly on plans for the next day's activities. They had no time to lose; one team would start building forms for the launch pad while another started work on lifting the missiles out of their silos.

Once the business of the day was done, everyone on the Colorado team wanted to get to know the new additions. Until then, Lloyd had been feeling out of place, a jack-of-all-trades at a convention of experts; but personal contact with the engineers from Colorado Springs laid his fears to rest. The engineers could work out the theory for their rocket to the last detail, but none of them knew where to begin when it came to actually making the parts they would need.

Lloyd was mobbed with people during the impromptu party, but he soon realized they were more interested in Bailey than him. Few of the Colorado team had met an expectant mother before. She was her usual gregarious, talkative self, but he noticed she would not leave his side. She stayed in physical contact with him, clinging to his arm, sometimes with both hands.

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As the volunteer for the suicide mission, Wayne became an instant hero, but Ozzie turned out to be the true celebrity among Lloyd's friends. Ozzie was the catalyst, the one who had brought this whole team together. Even Colonel Masters deferred to him. Within minutes after the formal meeting broke up, it was obvious that although Christie Masters would continue her role as camp boss and head of the rocket team, Ozzie would be the leader for the whole project. Everything they had gone through, and everything they would do, was for the sole purpose of providing Oswald Gundersen with a few pieces of vital information about the plague virus.

Long past midnight, they wandered sleepily back to their trailers.

"*Again?*" Lloyd asked. He felt groggy. Their first day at the rocket camp had been long, exciting, and both physically and mentally exhausting. He'd been about to go to sleep.

"Please, darling, if you can." Bailey wasn't purring or cooing to him, she was pleading. She moved against him, holding him as if she were afraid he might slip away. It had been like that for hours. He enjoyed it all, but sometimes he felt she was trying to crawl inside him.

"We can always have fun trying! But give me a few minutes. Bailey, are you all right?"

"All those people!" she murmured. "I've never seen so many people in one place before. The way they looked at me, talked to me. I'm scared, Lloyd. I can't even remember their names!"

"Don't worry," he said, stroking her hair. "I didn't catch everyone's name, either. We'll learn them soon enough."

"But, the women—" He could hear the bewilderment in her voice. "All they wanted to talk about was what it's like to be pregnant. Even Christie. Is that what women used to be like?"

"Women once had a special interest in such things. It's been a long time since these women have had a chance to think about anything but survival. They need the feminine contact. But that will pass, too, as we get to working with them."

"Uh huh. They aren't very feminine."

"Afraid to be," he said. "They have a different culture. In Gold Bar, we learned to deal with not touching each other by being outrageous about it. In Colorado, they suppress their sexuality entirely. Same problem, different ways to cope."

"I like our way better."

"Me, too."

She nestled her head in the hollow formed by his hipbone. "I can't imagine what it must have been like, before the plague."

Lloyd stared into the darkness. "Sometimes, neither can I," he whispered.

Twenty years of rust made the job of cranking the cap off the missile silo an exercise in tedium, but finally sunlight shone down the deep concrete well. Lloyd descended metal rungs running down the wall of a tiny shaft

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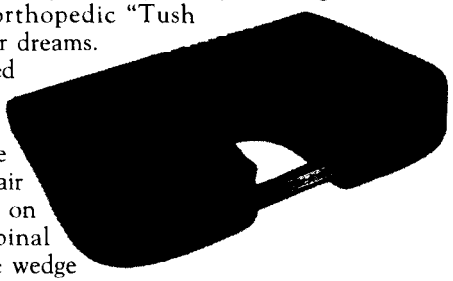

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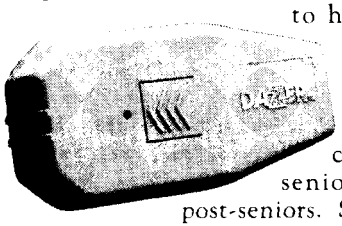

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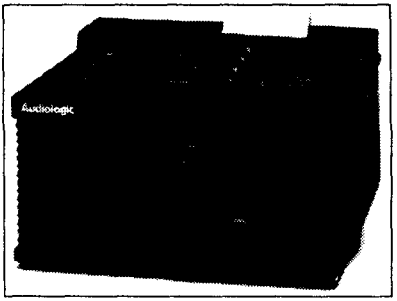

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parallel to the silo, taking care to place his hands where others' gloves had polished off the rust. Odd scents penetrated the filters of his isosuit. The medicinal odor of iron oxides combined with stale, damp air to make him feel as if he were disturbing an ancient tomb.

A pair of missileers had managed to activate the missile test console at the maintenance level. "OK, Lloyd," one of them said. "Ordnance is clear. They have the warhead lifted out, and the bird checks out safe. Go up and gawk all you want."

"The electronics are still working after all this time?" Lloyd asked.

"These babies were made to last!" the missileer said with chest-swelling pride.

Lloyd climbed another set of rungs set in the wall of the silo itself, up to the level where the deadly warhead had been.

"Some crystallization in the metal, Colonel," he reported through his radio. "But it looks like it's just on the surface. Down here, radiation seems to be a bit lower than on the surface."

"I'm not surprised. You're better shielded down there," Christie explained. "And there shouldn't be any residual radiation from the warhead. Ready to check the lift points?"

"On my way down." He descended to near the center of the missile, gingerly searching out each rung below him with his toes. There, he unbolted an expanded-metal catwalk and carefully let it swing into place.

"No visible leaks at the field joints," he reported. "And my sniffer doesn't detect any fuel or oxidizer. The lift ring looks solid, shiny as if they'd just come off the mill."

"Excellent! I expected as much. The hardware has a plastic coating to protect it. Console, how's our status?"

"The bird's ready to fly, Colonel." He recognized the voice of the missileer he had talked to earlier. "All we'd need is the enable code and we could launch her right now!"

The officer's comment was more disturbing than comforting to Lloyd. "Y'know, Christie, it's frightening to think this death machine has been here under the desert all this time, just waiting for a launch command."

"Yeah, this one, and a couple hundred like her," the colonel said. "This was my missile wing. That's why we picked this spot." He could hear her tone brighten even over the radio. "But maybe we can reverse her destiny! Heads up, Lloyd! Here come the lift hooks!"

They worked through the winter, disarming missiles one by one and lifting them from their silos. Lloyd and his team of apprentices machined the parts they needed to cluster and stack the rockets at the new launch pad. Their launch vehicle would be ungainly and notoriously inefficient—advances in targeting and the design of nuclear weapons had allowed engineers to design ever-smaller missiles to deliver the deadly payloads. In those days, no one had thought that one day these missiles would be stacked to carry a heavy spacecraft all the way to orbit. The parasitic weight of combining individual launchers grew exponentially

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as the stack built up.

Bailey spent most of the daylight hours with Wayne, helping him review the flight plan and learn the laboratory procedures he would need if he succeeded in reaching the space station. She invested her evenings in socializing. With Lloyd's assistance, she started a sewing class, and soon her infectious personality had spread throughout the camp.

An enclave of helpers grew up around Ozzie. His multiple roles as the project leader and the camp's only doctor would have swamped him, but there were always volunteers ready to lighten his burden. Colonel Masters had a desk moved into her office for him, and from there the two of them ran the project.

They dispatched a small team to Houston with one goal: to retrieve a truckload of spacesuits and life support equipment from the abandoned space center. When the Houston scavengers returned, Wayne began the final phase of his training. He learned to operate his reconditioned suit, and became adept at controlling his tiny spacecraft in a makeshift simulator.

Finally, they were ready. An early spring gave them a perfect day for their launch attempt—clear and cool with only vague, shifting breezes.

"Three. Two. One. Ignition!"

The launch sequence was automatic, but it made Lloyd feel good to call out the familiar countdown. Bailey sat next to him in the blockhouse, cheering at the top of her voice. Despite her enthusiasm, she was obviously making an extra effort not to jump from her seat; her belly was huge under her modified isosuit, as close to full term as Ozzie could predict. Ozzie stood over her, watching Bailey as much as he did the clouds expanding from the launch pad.

Borne on wings of fire, Wayne's spacecraft lifted off from the missile test range. The first stage was a cluster, with eight strap-ons aiding a larger central rocket originally built for military launch-on-demand missions. The rocket thundered into the sky out of view of the blockhouse windows.

"Perfect trajectory!" the guidance officer announced.

Lloyd joined the crowd running out of the blockhouse, closely followed by Ozzie. He was momentarily embarrassed that he had not thought of Bailey when she waddled up beside him and took his arm.

"Coming up on staging in thirteen seconds," Hubert said. Lloyd was surprised to see the boy looking at his watch instead of at the rocket, but that was Hubert for you! "First stage burnout, second stage ignition . . . *now!*"

"Second stage looks good—" One of the engineers next to Lloyd started to say something. Then, "Uh oh!"

"Huh?" Then he saw it. "Oh my god—"

"*What happened?*" The shriek came from Bailey.

"Third stage," the engineer stammered. "It ignited. Along with the second."

Lloyd turned his eyes away from

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the fireball in the sky. There were confused shouts, laced with strangled invectives.

"Range safety!"

"No RSO for this flight!"

"Where will it land?"

"Don't know!"

Lloyd looked to Bailey, but she was staring past him. Her chin quivered; tears welled up from her eyes. She inhaled deeply and then exploded, loud and long and almost unintelligible, "*Wayne!*"

Her full weight bore on his arm so suddenly he had to kneel to keep her from falling. Pale, translucent fluid was soaking through her slacks, puddling in the feet of her isosuit. He called for Ozzie.

"No panic." Ozzie slipped into his doctor persona, trying to reassure them both. "We have plenty of time. It looks like your water broke, Bailey. It should be just a few hours now!"

Just before midnight Central Whatever Time on the Ides of March, 2025, Mercury entered its retrograde phase in Aries, the Moon entered Libra, and Maximilian Tompkins Fletcher entered the world of breathing creatures. By one o'clock the next morning, the news had passed to everyone in the camp: a boy, seven pounds ten ounces, light hair, blue eyes; mother and baby are doing fine.

Ten months later, Camp Wayne Braun saw a false dawn as a dozen solid motors ignited simultaneously and thundered their defiance of Earth's gravity. Spaceship *Caduceus* lumbered toward the sky. A tiny alu-

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minum sphere rode atop a pyramid of ancient missiles, carrying a lone space traveler and a precious cargo of supplies, biological samples, and live mice. Previous manned space launches had attracted more than a million cheering spectators; this time there were less than a hundred, all encased in isolation garments. The buzzing of breath masks made their collective cheers sound like a plague of locusts calling in chorus with the din of rocket engines.

The first stage burned out barely half a mile from the ground and dropped back onto the desert sand. The second stage cluster made it four times farther before falling into a pine forest, starting a fire which would burn all summer. *Caduceus* disappeared into the glare of the rising Sun on the eastern horizon.

Lloyd Fletcher looked away from the spectacle of the sunrise to admire the ten-month-old baby in his arms. Inquisitive blue eyes beamed back through the infant's minuscule breath mask, intently watching Lloyd's face for cues about how to react to the noise and commotion.

"Don't worry, Max," he assured his son, striving to keep his voice calm and melodious. "Mommy will make it." He wasn't exactly lying. Intellectually, he knew there was little hope that he would ever see his wife alive again; but deep in his soul he couldn't accept it. She *would* make it home. She *had* to.

"She'll make it," Ozzie echoed. "The gods preserve her."

Despite the crushing acceleration and terrifying metallic groans from her tiny spacecraft, Bailey was exhilarated. She rode toward the heavens on an adrenaline rush more powerful than anything she had known before.

The debate over who would make the perilous trip aboard the *Caduceus* had not lasted long. Among the eligible participants in the project, she was the youngest, the most athletic, and the most determined. When Max was born, it only increased her determination. She told Lloyd she would prefer to die in an attempt to free her child from the horror of the plague rather than live to watch him die a slow, degenerating death.

She knew a sizable area of Baton Rouge would be destroyed by her third stage rockets, but there was no one there to care, no insurance investigators to assess the damage and no lawyers to threaten litigation. When she felt the third stage separate, Bailey enabled her fourth set of rockets. The missileers had balked at giving her manual control, but it at least eliminated the risk that she would repeat her brother's fate. The fourth stage cluster eventually fell into the Atlantic off the coast of Florida. She was more than halfway to Africa when the fifth stage separated.

Finally, *Caduceus* achieved orbit. Through a single window set in the hatch in front of her, Astronaut Bailey watched a few dim stars peek through the sunset glow ahead.

She invested a full minute in a rush of awe, waiting for her sense of wonder to adjust to actually traveling in a spacecraft orbiting the Earth. All astronauts before her had gone through

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hundreds of hours of simulations to prepare for their missions, but for her there were only a few practice sessions inside her spacecraft and a general outline of what she was to do. No familiar memories from simulated starfields and Earth models dulled her excitement at flying in space for the first time.

Caduceus sailed silently into night. Someone had meticulously painted the space station's predicted orbital path among star charts on the inside of her craft. Unwilling to entrust such vital information to her memory, she had traded her underwear for the charts; the missileers had begrudged the weight of even that much paint. With her helmet firmly lodged in its cradle, she sighted her guide stars through marks on the viewport.

Two hours of star sightings and patient observation of ground features assured Bailey that her orbital inclination was as close to the station's as she could measure it. She fired her maneuvering jets to raise her perigee, so she would orbit the Earth a bit more slowly than the station, allowing it to catch up with her.

For six hours, four sunrises and sunsets, it was a waiting game. She followed her position on a map of the Earth, comparing where she was to where the station should be, and tried to become accustomed to weightlessness. It was just like they said on the videotapes; once you got used to being disoriented, there was no real sense of up or down.

She decided to pass the time by investing a few minutes of videotape to photograph the Earth. But when she turned her camera on, a battery warning message winked briefly before the viewfinder when blank. She tried again; same results. On the third try, she didn't see even the brief flash of a battery warning. When she tried her spare battery, the camera ran for exactly nine seconds before shutting down. She released the camera from her gloves and stared at it, watching it rotate lazily in front of her face plate.

The camera had to work. It was a vital link in her plan. The camera would capture pictures of her experiment results, so she could digitize the images and transmit them on a modem carrier through the space station's voice link to Hubert. But it wasn't working. There was nothing she could do but try to relax and enjoy the view as the Earth slid by beneath her.

By the time her computer and her paper charts agreed that she should be sitting on top of the space station, the candy bar attached to the inside of her helmet was gone, she was out of drinking water, and her diaper was soaked through.

The hero of the first space age who first wore Bailey's suit had been just the right height, but she wished his hips had been broader. Her pants had seemed comfortably snug on the ground, but now they began to press painfully on her bladder. She didn't know what would happen if her diaper overflowed. When she first tried on the suit, she was happy to learn its previous owner was a muscular, barrel-chested man; there was just enough room for her maternally enhanced figure. But now that zero

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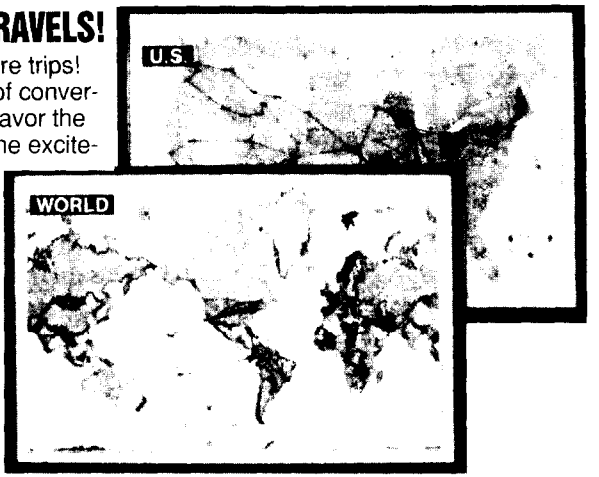

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gravity was causing fluids to pool in her upper body, she was no longer so sure of comfort in that area either.

When she was finally confident that the station should be just ahead of her in the same orbit, she began her visual search. There was no tracking satellite to help, no rendezvous radar. She scanned the pinpoints of light in the surrounding blackness, hoping to spot a special star, a single bright spark which appeared just before sunrise and just after sunset.

Two orbits later, she saw it—a star which refused to move with the other stars! Bailey whooped in elation. Throughout another trip around the Earth, she nudged her tiny spacecraft closer until she was flying in formation a thousand feet behind her target. She wistfully admired the vision of sunlight glinting off its huge solar power wings. Dark trusswork formed an elusive silhouette against the black sky, giving the station the appearance of several separate spacecraft orbiting together.

She had no way to dock with the station; the docking mechanism alone would have weighed more than her entire spacecraft. Instead of attempting to maneuver to the docking ports at the front of the station, she picked a spot on the truss that didn't seem to have too much vital equipment. Keeping that spot centered in a reticle painted on the forward viewport, she crept up on the station from behind.

"Patience, Bailey, patience," she whispered.

The station was less than a hundred yards away, slowly drifting toward her. She fought an adrenaline rush, shaking her head to dampen the sound of blood pulsing in her ears, and thought of the dwindling population down there on Earth's surface. Her infant son's future depended on her ability to get aboard the orbiting laboratory. She had to get it right.

The target hardly wavered in her reticle. Trying to ignore her pounding heart, she depressed a switch. There was a dull clank, and a silver dart shot out from beneath her. A line of white nylon climbing rope trailed behind, marking its progress.

Before the dart was halfway there, she could see it was a clean miss. Her shot was too low. She swore in anguish and pounded her fist on her armrest as the dart passed below the station. When it reached the end of its line, the dart abruptly halted its flight and blossomed into a bristling mass of long, thin tubes. A moment later, she felt a tiny jerk on the messenger line, and her spacecraft began to rotate in response. The station silently slipped out of view through the bottom of her little window.

Her hand automatically went for her control stick, but Ozzie's coaching echoed in her mind. "Save your fuel, Bailey. Wait for it." She stopped short, her glove a scant fraction of an inch from the controller. The temptation to use her thrusters was almost overwhelming. Agonizing seconds passed as stars crawled down her viewport.

There was only one way to retrieve her dart; she had to go outside and get it. The idea of leaving the safe

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confines of her tiny spacecraft was frightening, but at least it gave her something to do. She opened a valve and gritted her teeth, feeling her suit stiffen as the *Caduceus* vented down to vacuum. Earth replaced the starfield in her window, its browns and blues winking through its garment of brilliant white clouds. Finally she again saw dark sky, and the station reappeared, looming much larger now; closer.

"Relax, relax." Her hands would not stop quivering. She gingerly nursed her control stick until the space station was again steady in her reticle. To her horror, the station started to drift the moment she released her controls. There was nothing to be done about it; she let her spacecraft drift.

Swallowing her exasperation, she unfastened her harness. Stiff gloves made it a clumsy affair to tie a nylon line to her suit, but the resulting knot looked secure enough. She undogged the hatch and pulled herself out, and found herself looking straight at the Earth.

Down! Earth was *down!* She was *falling!* She closed her eyes and reswallowed her bile. With deep breaths through her nose, she struggled against nausea and vertigo.

When the wave of illness was past, she rotated herself around in the hatch with her eyes still closed. Gripping the edges of the hatch allowed her to stare inside, taking comfort from the familiar appointments of her spacecraft while she waited for the dizziness to settle down. When she was finally able to look out again, she saw the space station, just a few yards away. It took a moment for the scene to coalesce in her mind; finally it snapped into place. She was looking at the underside of the station, the side which faces Earth. She was below it, and moving past!

She had to work fast. Since *Caduceus* had no external handrails, she had to hang onto the edge of the open hatch with one hand to swing her feet beneath her spacecraft. Her dart, now a shimmering silver umbrella, was twisting on its line far below. She could reach just far enough to hook the line with one boot, but it was enough. She remembered her lessons and gathered in the line only as fast as it drifted toward her. If she pulled on the line, she would continuously accelerate the dart until it smashed into her fragile spacecraft with disastrous speed.

With the dart in hand at last, she collapsed its spines and stretched to slip the projectile back into its barrel. It went in easily at first, but balked when it encountered its propulsion spring. She pushed harder, but only managed to rotate herself away from the launching apparatus. She tried again; same results. After several more trials, she learned that by swinging her body she could use her own inertia to force the dart into its seat. It snapped into place with a tactile click. The nylon line still drifted in loops and spirals below her, but she didn't think the tangles would matter now that she was in space.

The station was farther away, and visibly growing smaller by the time she was back in her seat. She carefully

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sighted through her reticle. Her stablilization maneuver had not gone well; her fuel gauges were pinned on empty. There would not be another chance. Again she selected her spot on the truss and waited for it to drift into her cross hairs, hoping she could guess the dart's time of flight well enough to properly lead the target. When it felt right, she fired.

Her heart stopped when the dart caromed off a piece of equipment, but it bounced inside the trusswork. With terrifying lethargy, it drifted through the truss and appeared as a shining wand against the black sky on the other side.

"Time to set the hook," she quipped. There was no time to lose. After scrambling outside again, she reached around with her foot to retrieve the messenger line. She yanked on the line, *hard*. The dart halted abruptly in its flight and again popped open to reveal its shiny metal spines. To her great relief, the dart became an anchor, lodged against the space station's trusswork.

She felt the tears coming, but with her space suit on she couldn't reach her face to wipe them away. Instead of running down her cheeks; tears welled up in her eyes. The world blurred out as she groped her way, sobbing but happy, back into the *Caduceus*. For a few minutes, she indulged in a good cry, triumphantly congratulating herself on achieving her goal.

Eventually, she discovered she could clear her eyes by blinking and shaking her head violently. Tears spattered against her faceplate. The head-shaking left her dizzy and nauseous, so she waited for the world to settle down.

When she was finally ready, she reached through the open hatch and retrieved the messenger line, only to discover she was now above and behind the space station. She saw the problem in a glance—the *Caduceus* was circling the station, wrapping its anchor line around the truss. Carefully, she towed herself in.

If the three-hundred-ton space station noticed the disturbance when her tiny craft bumped into it, she couldn't tell. She took a few deep breaths before continuing her flight plan. Time was of the essence; that thin nylon line would quickly turn brittle at two hundred degrees below zero.

Her plan called for running aluminum wire from pad-eyes on the *Caduceus* to the trusswork, but her gloves made her feel like she was trying to thread a needle while wearing welder's mitts. Each piece of wire thwarted her time and again before it finally consented to enter the hole for which it was destined. She struggled on, shaking tears of pain from her eyes as her gloves rubbed her fingers raw.

The station's interior was at vacuum so she expected to have no difficulty cranking open one of the hatches, but when she pulled out the handle on the nearest hatch and tried to turn it, it wouldn't budge. She braced herself against the hatch and used her leg muscles to drive her shoulder against the stubborn handle,

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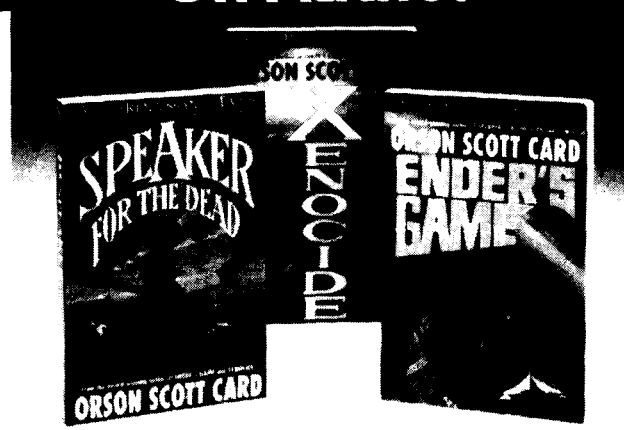

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but the latch still refused to open. A vague memory came to her, something one of the Colorado Springs engineers had mentioned: vacuum welding—sealant had deteriorated from years of neglect allowing metal-to-metal contact. The subject came up several times while they were planning the mission, but they ignored it because there was no solution. If a hatch had welded itself shut over the years, it would be impossible to get into the station unless she destroyed the hatch. And without the hatch, she couldn't repressurize the station. It was just another item on the paranoia list, just another thing that led to irrecoverable mission failure.

Bailey didn't believe in mission failure. She wouldn't live to see the results of her sacrifice, but she *would not fail!*

She tried other hatches, same results. Most of the hatches still had covers bolted over them, harbingers of plans for expanding the space station in a future that no longer could be. The airlock and the docking mast proved to be equally reluctant to accommodate her entry. Finally, she gave up; she was too exhausted to go on, and her exertion had driven her oxygen pressure gauge dangerously near zero. She allowed herself a few minutes of rest while clinging to a yellow handrail mounted on one of the station's modules.

"Think, Bailey, *think!*" she whispered. It took all her will to ignore the pulsing flames of pain in her knuckles. "You've come too far to fail just because you left your house keys behind! How are you going to get into this can?"

But no thoughts came.

In her frustration, she pounded on the site of the station, screaming invectives at the recalcitrant hatches. The blow brought waves of agony to her tender hand, but the pain only increased her anger and frustration. She hit the station again, even harder.

It bent.

She was amazed at how flimsy the structure was. A brief exploration revealed small latches holding a debris shield that opened like a giant door, exposing the aluminum skin of the pressure vessel. Beneath the shield she found the small crater her fist had left in the skin.

To open a can, you need a can opener.

She didn't have a can opener, but she did have the wire cutters she had used to tie down the *Caduceus*. With the wire cutters held tightly in her fist, she slammed the point of their jaws into the skin of the station's control node. The cutters went through, leaving a small hole with terrifyingly jagged edges. A vision of those sharp edges ripping through her space suit played in her mind. She needed something else to widen the hole, but except for the wire cutters and her flashlight, she had no tools.

"Tools, Bailey! *Think!* Astronauts used to work outside this thing all the time. Where would they keep their tools? Right where they come out to do their work!"

She checked around the airlock, but couldn't find anything that looked like a tool box.

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"*Wrong!* Lloyd doesn't keep his tools by the front door! Why carry them all the way out to the car every time he needs them? He keeps some of them in the garage, and some of them in the Suburban!"

She found them, the little carts astronauts used for moving their equipment along the station's main truss, hitched up to the huge robot carrier. And, to her delight, she found the tool boxes. Each cart had its own tool box, a treasure trove of implements which could be pressed into her service. She ignored the things that looked like electric drills—their batteries were undoubtedly defunct—but the socket wrenches looked hefty enough to mash through the thin aluminum balloon of the station's pressure vessel. Little boot platforms attached to the carts looked even beefier, but she couldn't figure out how to get them loose, so she settled for the wrenches.

It seemed odd to hear no sound as she pounded away at the rent she had opened. Only the peaks in her hand's incessant protests told her when the heavy end of the wrench made contact. After a few minutes, she had opened a Bailey-sized hole in the station's side.

She beat the sharp edges back until they were no longer quite so scary, and poked her head in. It was dark. When she fished her flashlight inside, she saw to her great relief that the hatch leading from the node to the laboratory module stood ajar. Inside the node, she realized how lucky she had been. Her hole was between a pair of stand-offs holding equipment racks against the wall. A few inches to either side she would have encountered solid structure, but her entry had only damaged a few bundles of tiny wires. She hoped the wires were not important.

She found she could move her equipment with relative ease by attaching it to her suit. A handful of short lines from the astronauts' toolbox, each with snap hooks at both ends, were perfect for the job. It was just a matter of making sure nothing snagged as she pulled herself along the truss. When she could, she used her hands as clubs to alleviate the fatigue mounting in her fingers. Eventually, shaking her head to clear away sweat and tears, bone-weary from her long day, she had all her equipment inside the laboratory module and all the lab's hatches securely closed. She didn't know if the lab would hold pressure, but she was too exhausted to care as she cracked open the valve on her first oxygen tank.

Dumbly, she watched the pressure gauge climb.

The outside world reached five pounds per square inch, and a mechanical telltale indicated the regulator had shut off the flow. Bailey watched the gauge for a few minutes to make sure it was holding steady, and then skinnied out of her suit. It felt good to be released from the stiff, confining garment.

The laboratory was *cold!* Her breath condensed into fog which frosted on the instrument panel in front of her. She shivered as goose bumps broke out all over her skin. But she was too happy to be able to

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move freely to notice her discomfort, and too weary to care. With some towels that had waited for almost two decades at the space station, she cleaned herself off.

She was too excited to sleep, but too rummy to risk trying to activate the laboratory until she had slept. So she settled for exploring the nooks and crannies of her orbiting environment, being more than careful not to bump into anything that looked like a switch or a valve. There were some insulated jumpsuits in one of the lockers that might fit her, but she was reluctant to put them on; they reminded her too much of an isosuit. All her life, she had been confined inside an isosuit, until that first wonderful night with Lloyd. Besides, the atmosphere was warming up as the station's heaters did their work on the oxygen she had released. For the first time, she could luxuriate in complete freedom, dressed only in her skin in zero *g*.

She wished she could share the experience with Lloyd. She missed him terribly, and tried to tell herself not to think about him. That was her private plan for coping with the fact that she would never again see Lloyd—just don't think about it until it was too late to matter. She had to do it, for him, for baby Max, for the survival of all the people on Earth. But alone and weary in the dimly lit space station, she found she could think of nothing else. Someone else could have done this suicide mission. Why had she campaigned so hard to be the one? At that moment, she could have been at home, with Max happily suckled and sleeping, and Lloyd's arms enfolding her, keeping her safe, protecting her, loving her.

Instead she was here, trapped in a tiny metal can where there was no up or down, cold and lonely and dizzy and hurting. She had chosen her own destiny, but how could she have done this to herself? Max would grow up without her. Lloyd might find someone else for him to call mommy, someone to tell him of his heroic mother who died to save all mankind. But Max would never know what it was really like to spend her last few days so far away from him, her breasts painfully engorged and leaking milk that should be helping him grow, wishing she could hold him if only for a few minutes. *Oh, Max! Mommy did this for you!*

Her tiny world blurred out. With chagrin she realized that once again she needed something to dry her tears. Groping around, she found something made of soft cloth—one of the quilted jumpsuits she had carelessly allowed to float free in the laboratory. Clinging to the garment, she hugged it to her, wrapped her arms and legs around it, and buried her nose under its collar and wiped her eyes. The suit had lots of pockets, like some of the things Lloyd wore. If she just ignored the fact that it had no hands or feet, she could pretend for the moment it was him.

Bailey found herself floating upside-down in the laboratory when she awoke, still lightly embracing the jumpsuit. After breakfast on water and granola bars, she went through

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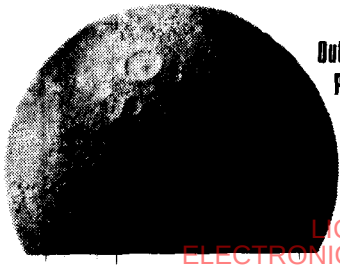

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her checklist to activate the laboratory.

"Welcome aboard!" A disembodied baritone startled her the moment she activated the lab's computer system. Her fingers flinched back from the control panel. The voice, accompanied by rattles and buzzes from speaker cones embrittled by exposure to vacuum, resounded through the laboratory.

"Uh, can you hear me?" She didn't know which way to turn to address the speaker.

"Yes, quite clearly," the voice said, "though I don't sound very good, do I?"

"I can understand you well enough." She was still looking for the source of the voice. It must have come from several grilles set in the laboratory ceiling. She addressed the nearest grille. "Who are you?"

"I am Space Station Freedom. You may call me Freed for short. Everyone else does. Who are you?"

"Bailey Tompkins. Uh, I guess I'm an astronaut, sort of."

"I am pleased to meet you, Bailey Tompkins. Colorado Springs informed me of your flight plan, but I received no rendezvous and docking sequence."

"Well, I didn't exactly come in the front door."

"I have a status report when you are ready," Freed said.

"Yes, please, give me the status report now."

"There are criticality-one failures in life support systems throughout the station due to exhausted atmospheric gas supplies," Freed went on in a monotone. "All modules are at zero pressure except the life sciences laboratory, which is pressurized from an unknown source. Warning: atmosphere in the laboratory is sufficient to sustain human life, but there is no nitrogen in the mix for fire suppression. The control node recently received multiple severe meteoroid strikes and is logged for unscheduled repair."

She wondered if she should interrupt to explain that she was the source of the damage. She decided against it.

"All emergency crew return vehicles have been used, except number four. That unit is inoperable. . . ."

Freed went on for fifteen minutes, cataloguing the space station's ills. She chuckled when he complained that scheduled repairs on the thermal control system were six thousand hours overdue, but his report on the main propulsion system was sobering. With his fuel exhausted, he predicted entry interface in four hundred days. In just over a year, there would be no more Space Station Freedom. Her mission was the last hope for warm-blooded life on Earth.

She winced when he complained that the meteoroid incident had damaged the forward data feed from laboratory experiment racks. It didn't seem like the right time to tell him that she was probably the meteoroid strike. She listened patiently, trying to absorb it all until she concluded that she would be able to complete her work in the laboratory. Her useful time would be limited by the supply of oxygen she had brought with her,

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not by deterioration of the space station's systems.

She had come to do a job, and it was time to get to it. Reluctantly, she pulled on her isosuit. The first procedure was the one she dreaded the most. All but a few of the mice had survived the two days they had been locked inside a pressurized cage, and she cried when she had to kill the tiny creatures. Part of it was sympathy for the mice, but mostly the idea of killing any warm-blooded animal horrified her.

Using the laboratory's compact centrifuge and distillation equipment, she prepared her first experiment with blood and tissue samples from one of the mice. Everything went well until she was ready to set up the reaction chamber where her protein crystals would grow.

The station's crystal growth chambers didn't look at all like the equipment Ozzie had taught her to use. At first she tried to puzzle out the function of each piece of the apparatus, only to realize she didn't know how the equipment on the ground had worked. Her days of training had been invested in memorizing rote procedures rather than actually learning what she was doing. Temperature, airflow, the quantities or reagents, all were critical. She thought she had them memorized, but all she had learned was where to set the click-stops on a completely different set of equipment.

If only I had paid more attention to Ozzie's lectures, she thought. *This is a task for a real scientist, not a cookbook lab tech.*

There was one chance. Ozzie had made a videotape of the laboratory procedure for her, demonstrating the process of growing protein crystals from a droplet at the end of a pipette. She had seen the tape a dozen times, but this time she wasn't just after the video; her goal was Ozzie's chatty voice-over, meticulously explaining the reason for each step and how varying the settings would change things.

A small television set in one of the laboratory racks showed snow when she turned it on. It seemed to be working, a fact which Freed confirmed. She checked the videotape player next to the TV and shook her fist in triumph—the format was the same as Ozzie's tape. A brief conversation with Freed revealed that several dozen entertainment tapes were available, just out of reach in the depressurized crew quarters next door. No matter; she hadn't come here to watch old movies.

Seeing Ozzie's tape cassette again made her chuckle. The engineers had drilled the plastic full of holes—anything to lighten their rocket's payload. With high hopes, she inserted the tape into the lab's player.

Nothing happened. The tape would not even load.

"Freed, the video machine isn't working! What do I do now? All the video equipment I brought with me is worthless!" She looked at her camera bag with disgust. "And to think I could have traded it for a couple sandwiches and a dozen pairs of clean panties!"

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There was a short pause. She was getting used to this; it meant Freed was thinking about her question. Finally, the station computer said, "The most likely source of failure is the elastic polymer bands which drive the tape transport mechanism. They probably have crystallized in the vacuum environment. The unit is beyond repair. I have logged an order for a replacement unit on the next logistics flight."

Next logistics flight? She didn't know whether to laugh or cry.

"Why do you not view the tape on your own video equipment?" Freed asked.

"My camera battery's dead. I don't suppose you have a spare."

The computer wanted to know the make and model of the camera. When she described it in detail, he said, "I do not have a replacement battery in my spares inventory."

She knew it would have been a miracle of luck if the station had happened to have the right battery on board, but she felt raging disappointment nonetheless. "Damn! Freed, do you have any ideas?"

"What is the function of the battery?" the machine asked.

His matter-of-fact manner reminded her of Ozzie. It raised her hopes. "Uh, the battery provides electrical power to my camera."

"Please quantify electrical power."

She read the fine print on the battery's label.

His answer justified her hope. "I can provide twelve volts direct current."

With his guidance, she took the front panel off the metallurgy rack and tapped into one of the computer power supplies. The camera's receptacle for external power was a later design than anything Freed could accommodate, but a pair of wires requisitioned from a plant growth experiment did the job. As soon as she hooked up the power, her camera lit up. Familiar images of Ozzie's laboratory appeared on its tiny monochrome screen. Her jubilation was tempered by a maudlin ache; she wished she could be back there again, sharing the excitement of planning this mission with her friends.

After Freed told her which panel to open so she could patch the camera into the station's television, she spent the next several hours repeatedly viewing the tape and taking meticulous notes. The hardest part was one scene where Lloyd had come in with Max, interrupting their long hours in the ground-based laboratory so she could feed her baby. Her husband and son were on the screen for only a few seconds before someone had shut off the camera, but to her they were the most precious few seconds on the tape.

Hour by hour, crystals grew in the laboratory's test chambers. Once started, the process required no attention from her, so she busied herself by preparing the next sample until all the crystallography chambers were at work. Eventually she reached the point where there was nothing to do but wait.

With time on her hands, the ghostly thoughts which plagued her

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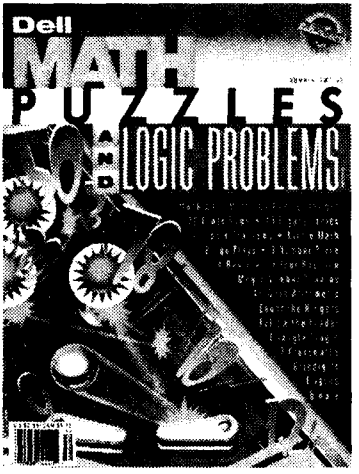

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on her first night at the station threatened to return. To fight off another descent into depression, she kept busy, repeatedly rearranging everything in the lab and pretending as best she could that she was back home in Washington, doing her housekeeping. At least, with the laboratory chambers once again sealed, she didn't have to wear her isosuit.

Despite her efforts to put her situation out of her mind, her second night aboard the space station was almost as bad as her first. The same jumpsuit, this time stuffed with towels to give it more bulk, helped her get through it. She used elastic bands from the lab's supplies to hold the suit firmly against a fabric-covered wall. When she turned off all the lights and sandwiched herself between the suit and the wall, she could almost imagine that she was home in bed with Lloyd. It was a poor substitute for her husband, more a scarecrow than a teddy bear, but it was all she had.

On her third day aboard the space station, she set up the X-ray interferometer. The lab had an elegant electronic imaging system, but Freed had more bad news. All the imagery data were fed to the system through the forward data feed lines. She only half-listened as the computer once again reminded her of the meteoroid incident which occurred the day she arrived on board.

She was almost glad to hear the disappointing news; it gave her a minor victory to celebrate. It felt like she had finally managed to get one up on the computer.

"That'll slow me down," she said, "but for once you've given me a problem I can deal with!"

The equipment was designed to accept the photographic plates she had brought with her. Two days and several hundred photographs later, she had her prize. They didn't look like much, just a sheaf of black-and-white negatives with pictures of geometric patterns, but locked in those intersecting lines and hexagons was the secret of life and death for all warm-blooded life on Earth.

There was one thing left to do—get the information back to the microbiologists at home.

Discussing the end of her mission with Freed brought back the fears and regrets that had plagued her since her first day in space. She dealt with it by keeping her mind on the facts, not revealing to the machine how she felt about it.

"Then you do not plan to survive your return to Earth's surface?" the computer asked.

"No. The engineers came up with lots of schemes for landing bags and rockets, but they were all too heavy. I couldn't even carry big enough parachutes to do much more than slow me down a little bit. *Caduceus* will be traveling too fast when it hits the ground for me to survive; but I brought an armored case for the negatives. If the recovery crew can find the wreckage, they should be able to recover the data."

"There is some doubt that they will be able to find the spacecraft?" Freed

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sounded incredulous. It was a dramatic departure from his usual friendly, businesslike manner. She realized he was used to the carefully planned precision of all previous space flights. He didn't comment on the anomaly of an astronaut making a one-way trip up from Earth, and she didn't ask what he thought about it.

"That's why it's so important for me to transmit the data to them. If it works, I can avoid the risk of the trip home altogether."

Finally she let herself think about the end. If she could send the data down by radio, she would stay aboard the space station. It didn't sound like such a bad way to end her life. The Air Force pilots had told her oxygen deprivation made them feel drunk; she would probably not even know when the end came. There would be another footnote next to her name in the history books: she would become the first person buried in space.

The alternative meant piloting her spacecraft until it crashed into the ground. It was a terrifying prospect, but the *Caduceus* didn't have an automated control system. If the negatives had to be returned to Earth, she had to go with them. She was determined to do everything she could do to avoid that scenario.

She couldn't suppress the wry thought. Caduceus, *ha! I should have named it the* Death Coach!

The glass panel of an experiment chamber served as a light table. She spent the next day recording the negatives with her video camera, feeding them directly into a digitizer in her portable computer. While she worked with the camera, she talked with Freed about the prospect of sending the data directly to Hubert. Her primary plan was to use the voice link and the computer's modem, but she hoped either Freed or Hubert had come up with a way to avoid wiring her computer into the station's voice circuit.

He gave her the bad news. "I am unable to acquire data from the laboratory. All our communication comes to me through direct analog circuits."

"Can I repair the data lines?" *Oh great! What else did I mess up when I cut through those wires?* Freed still thought a meteoroid strike had damaged the data lines. She still hadn't told him the meteroid was named Bailey.

Several seconds went by before he answered her question. "The nominal maintenance procedure calls for replacing the entire wire harness. I don't have a spare on board, but it may be possible to splice the wires. However, Colorado Springs is not prepared to receive data transmission. They are equipped for S-band voice only."

"Yeah, you told me that. Can you convert data signals to voice transmission?"

"Not from the laboratory. To transmit your data to Colorado Springs, I must convert from digital to analog, and then back to digital for S-band transmission. That capability is not in my software library."

"This is exasperating! Freed, how do I hook up my computer to the radio?" It looked like she would have

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to fall back on her original plan. The idea of tinkering around with her computer's electronics scared the willies out of her; she had no hope of figuring out how to fix it if she made a mistake. But there didn't seem to be any other way.

"You cannot. Communications controls are in the command node," Freed said. "That vessel is at zero pressure, and therefore is inaccessible."

"Can I splice into the voice wires from the lab?"

"It is feasible. However, the signal-to-noise ratio of analog signals from the laboratory is lower than allowable for modem transmission."

She looked askance at her space suit. "Then I'll just have to do it in the command node."

She waited while the lab slowly vented down. Finally she could crank open the hatch against the remaining atmospheric pressure. It was a lonely time; with her suit on, she had no one to talk to, not even Freed. Even her suit radio had been sacrificed to save launch weight.

The command node just wasn't designed for someone in a space suit. The only equipment with knobs and handholds big enough to accommodate her bulky gloves were the repressurizing controls next to the hatch she came in. She knew the procedure for repressurizing the node, but it didn't matter; even if she could spare the oxygen, the hole she had bashed into the side of the node would have made it impossible to bring that compartment up to pressure. She would have to work in her space suit, which meant moving around with just her fingertips gingerly pressed against unreasonably tiny handrails and making sure her big, clumsy boots didn't wreck anything.

During her training, she had carefully memorized the layout of the major work stations in the command node, but her helmet lights didn't illuminate enough area for her to get her bearings. Ghostly shadows threatened to foil the hours she had spent in the cardboard mockup back at Camp Braun. She couldn't find the communications controls; nothing seemed to be in the right place. There were a few familiar landmarks, but each time she turned or moved toward her next goal, she encountered the wrong console. On the verge of panic and dizzy from spinning around in vain attempts to sneak up on places that weren't there, she paused to collect herself.

"Admit it, Bailey," she said to herself. "You're lost. Now, what went wrong? They didn't have detailed schematics, but the guys who built the mockup were sure they had it right. Why? They had pictures, that's why. Recent pictures, the last ones the space station crew took before they got in their *Soyuz* capsules and came home. So who came up afterwards and rearranged all the toys?"

She didn't like the answer. "Oh, c'mon, girl, you don't believe in gremlins. Those pictures had to be right; you should have studied the pictures instead of spending all your time in the mockup. Geez, I wish I

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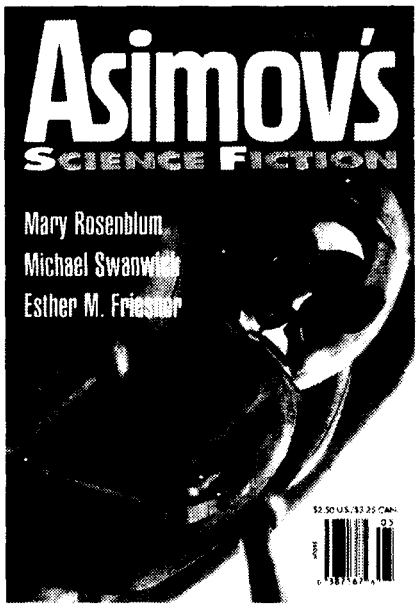

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could talk to Freed about this!"

A new thought suddenly popped into her mind. "Or Lloyd. He's good at figuring things out. What would he tell me to do? 'When something doesn't make sense, try looking at it from a different angle.' "

A different angle! She tilted her head, then rotated her whole body a quarter-turn to the right. The lettering on the consoles was sideways now, but the layout of the main systems console started to look familiar. *Thermal controls here, power on one side . . . and cooling water on the other . . . but they're backwards! That's it!*

Quickly, she flipped around the other way, exchanging the positions of her head and feet. Once her dizziness settled down—*gotta remember not to move so fast in zero g*—everything snapped into place. As long as she ignored the fact that the labels were all ninety degrees from vertical, it all made sense. The engineers had been just a bit too helpful. When they built the mockup, they represented each work station with a carefully labeled sketch. They made only one mistake; their mockup was rotated ninety degrees from the orientation of the actual space station command node. The labels looked right when she had viewed them standing up in the mockup, but each bit of equipment was exactly a quarter turn out of phase with the real thing.

"Now, if the power controls are here, then the communications controls should be right around . . . *here!*" With a whoop, she grabbed the equipment handles on the communications rack with her fingertips and mouthed a series of smooches at its enigmatic buttons and switches. All the time she had been searching, her goal had been just above her head.

"Oh Lloyd," she whispered, "thank you for being there when I needed you." She sniffed, but abruptly caught herself. "Damn it, Bailey! Stop that! This time you're not going to cry. You have work to do!"

There was only a patch of Velcro on her computer, but it was sufficient to hold the machine in place against a matching patch on the communications console. When she was satisfied her computer wouldn't float away, she reached another moment of truth. Either the cords she brought with her had the right connectors, or they didn't. The socket on the comm panel looked right and the pin pattern matched, so she held her breath and pushed in the plug.

No sparks. OK so far.

Her gloves made her fingers too bulky to operate the console's keyboard; she kept mashing several keys at once. That sent her on another tour around the command node, where she found a pen stuck to the power control console. Pushing the keys with the pen was slow going, but it worked. In a few minutes, the station was ready to receive her data. Thankfully, its voice recorder was all solid-state; there were no drive belts to worry about. One of the screens showed a picture of an oscilloscope and a little loudspeaker. The oscilloscope trace was flat, indicating the station wasn't getting a signal.

Now for her end of the link. This

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was easier; she'd had a lot of practice operating her computer's trackball with her gloved fingers. She couldn't feel the switch click with her fingertip, but the oscilloscope trace started to wiggle.

"Yahoo!" she cried. "For once, something worked right! Look out Hubert, here it comes!"

After a moment of arm-waving celebration, she programmed the communications console to transmit the analog message—actually digital data on a modem carrier—whenever the station was over an active ground station. That ground station would be Hubert. The thought made her chuckle. He had moved to Texas, but Freed still thought of him as "Colorado Springs."

She stayed there until her suit's oxygen supply ran low, gloating over the wiggling oscilloscope trace and grinning at her computer while it dumped its data into the station's voice recorder. The transmission was just getting started, so she left her computer where it was and returned to the laboratory.

When she checked her main oxygen tanks back in the lab, she was horrified at the amount of gas she'd used for her little sortie into the command node. The next time she ventured outside would be the last; there wasn't enough oxygen left for another repressurization. But she was confident; an unscheduled EVA notwithstanding, the procedure eventually went just the way the engineers had planned. Her mission was complete.

It had been another long, hard day, and she was happy to get out of her uncomfortable space suit for a well-deserved nap. A feeling of satisfaction filled her; as long as there wasn't a glitch in transmitting the data, she had managed to avoid riding the *Death Coach* back to Earth. Tomorrow, she could decide how to spend her few remaining days of life.

Freed woke her with the bad news. "Colorado Springs reports they are unable to separate data from the modem tone. There is too much noise in the S-band signal."

"Oh no! Does that mean there's no way to talk to people on Earth? I have to send these pictures to them!" If she couldn't get the information back to the microbiologists, all the effort they had put into spaceship *Caduceus* was for naught; she would have sacrificed her life for nothing. She was afraid she would have to ride the *Death Coach* after all, but it seemed Freed had yet another ace up his electronic sleeve.

"You can still record the images," he said. "Then I can transmit them when we have acquisition of signal."

"But you have all the images already stored in your comm system. Why do I need to record them again?"

"The pictures you previously recorded are stored only in the computer you brought with you. I cannot access them. You stored only analog modem signals in my memory—"

"—And that didn't work," she completed. "No need to remind me again. Can I patch my camera directly into you somehow?"

"Yes, my analog video circuit to the laboratory is intact. I must confess I

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have been watching your videotape along with you, Bailey. Please accept my apology for the intrusion."

"Oh no, you're welcome to watch," she said. "But now, tell me how to set up the camera so you can record the pictures."

"That will not work. Colorado Springs is not able to receive video data. Even if I could access the pictures in your computer, we could not use them. You must pixelate your transmission manually."

"Huh? How do I do that?"

She had to make one more photographic plate, this time with Freed driving the x-ray interferometer to imprint the negative. Once that was done, she found the job to be more tedious than difficult.

Back at her makeshift light table, she viewed the photographic negatives through an overlaid transparent grid pattern. The grid was small, but a tiny magnifier like a jeweler's loupe showed the grid and its index numbers clearly.

"Freed, record this."

"Recording."

"Subject number one, sample number one, interferometer at ninety degrees, point of view at ninety degrees. Begin. Fifty-six zeroes. Eleven ones. Twenty-nine zeroes. Four ones—"

She spent the next five days reading data from the negatives, pixel by painstaking pixel. Freed would still be transmitting the information a few minutes at a time over the slow voice link long after she had run out of supplies to keep her alive aboard the space station.

She thought the computer actually seemed happy to be working again. Between sessions, they chatted about her experiments and their importance to mankind. She had no idea whether the machine intelligence actually understood what they were talking about—she certainly didn't—but Freed seemed eager to learn.

She had been on board the space station for nine days when she had to face the reality that her time was up. The laboratory held pressure, but its aging seals allowed more leakage than any of the mission planners had imagined. Her last oxygen cylinder was gone. She was bitterly disappointed about running out of oxygen so quickly. It was bad enough that it meant the end of her life; on top of that, she hadn't been able to record even 10 percent of the data—data for which they had struggled so long.

Almost of its own volition, her finger depressed the rewind switch on her videocamera. The short video clip of Lloyd and Max began to replay; she'd lost track of how many times she had watched it that morning.

If only there were some way I could avoid having to fly the Caduceus, she thought. Her mind played out the horror of the crash landing and what it might be like. For the first time, she told the computer about her feelings.

"So you have two choices, neither of which is acceptable," Freed said.

"That's right. I can stay here and suffocate, and my mission is a failure. Or I can find a more creative way to die when I return to Earth."

"Your spacecraft has no facility for

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landing. Your body will undergo unacceptable accelerations upon interface with the solid surface."

Despite her mood, she laughed. Freed had such an entertaining way of putting things! However, the reality of her situation quickly came back to her. "If only there were some way I could get home alive."

"Analyzing."

"Huh? Freed? You still there?" Did the machine have feelings? Had she insulted him by laughing at him?

"Analyzing."

She couldn't get him to say anything more. Long minutes passed before he came up with a startling comment.

"Attempting to land without your spacecraft will also be extremely hazardous. You will lose most of your resources when you separate from the *Caduceus*."

"Freed, what the hell are you talking about?"

"You will find the necessary resources in the remaining emergency crew return vehicle," he said.

Everything was packed up and ready to go.

"Why have you not yet donned your pressure suit?" Freed asked. "At the current leak rate, I can support human life for only two hours more. Permanent neurological damage will occur before then."

"It's the longest time I've ever been able to go without having to put on my isosuit," she said. "And the freedom of zero gravity is something I just can't describe! Besides, I like what my body looks like up here!"

"What do you look like?"

"I didn't know you cared about such things."

"You are the first crewmember to come aboard without a photographic dossier," Freed said. "I used pictures to keep track of the crew while they were here. Now, I like to recall their images and think about them. Since you are the only crewmember currently aboard, I have not needed photo data to keep track of you; I get requests from no one else. But I would like to know what you look like."

"You have cameras, then? Why don't you just look?"

"You have not removed my lens cap."

She found the videocamera mounted in a clutter of equipment on the laboratory module bulkhead. With its lens cap on, the camera was just another piece of inscrutable equipment in the space station; she had never given it a second thought. With the cover removed, though, the function of the wide-angle lens was obvious.

"Hey, if you wanted to look at me, why didn't you just ask me to get in front of my camera while I had it hooked up?"

There was a short pause before he answered. "I was unaware your camera could transmit live images to my video system. I have now added that function to my inventory."

"Oh Freed, I don't know whether to think of you as a supergenius or a moronic child!"

"Neither would be an appropriate characterization. I am a machine."

She moved into the camera's field

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of view and tried to remain stationary, floating in the lab's central aisle.

"Well, what do you think?" she asked.

"I cannot resolve your flight suit. Where are your mission patches?"

"I'm not wearing a flight suit, or anything else for that matter."

"You are naked?" She thought she detected a note of surprise in the voice.

"Yes, I am. Haven't you ever seen a naked woman before?"

"No. Everyone else wore clothes anywhere I could see them. You are very beautiful."

"Thank you," she said. "But how would a computer know?" She knew she was attractive; she had been told so all her life. But coming from a computer, the compliment was incongruous. She hastily struck a more demure pose, making sure her knees were together.

"Your features fit well within the parameters for beauty which I have derived from several thousand hours of eavesdropping on conversations between humans. I like to look at you. May I see the other side?"

Realizing that the machine could actually care whether or not she was clothed made her feel quite self-conscious. However, the bent toward exhibitionism she had developed on Earth overcame her qualms. She turned to provide a departure view to the camera and looked over her shoulder. "How do I look from there?"

"Again very beautiful. Perfect within three decimal places."

She enjoyed the compliment, but had to scoff at the precision. "Three decimals places, eh?"

"It is an expression I overheard from a previous crew member. Is the expression inappropriate?"

She was quick to reassure him. "No, it was just right. Thank you."

"Are you well, Bailey? Your chromatic contours are varying rapidly."

Her cheeks felt warm. "I'm fine," she said, "but you've made me blush."

"I shall treasure these images. It would be a great tragedy if such creatures were to die out on Earth."

"Do you think we will?"

"Not this time. Colorado Springs reports that a team lead by Doctor Oswald Olaf Gundersen has narrowed the possible structures of viruses responsible for the plague to less than sixty thousand."

"Why didn't you tell me that before?" She didn't know whether to be elated by the news or exasperated with the computer.

"The subject has not come up before," Freed explained.

"Well, does that mean Ozzie can make his drugs now?" She was hopeful. Now that Freed had provided her with a tiny hope of survival, she was determined to attempt the kamikaze return flight; but it would be a great relief to know her mission had succeeded even if she failed to deliver the sheaf of negatives.

"It increases their chance of success, but their data are incomplete. They need the remaining images from your research."

She took a deep breath, and let it out slowly. "Meaning I still have to get the data to them myself."

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"That is the solution," he agreed.

Saying goodbye to Freed was the most difficult part of her departure, but the machine's comments as she stuffed herself into her spacesuit provided enough whimsy to get her through the process. Her figure had changed drastically during her stay at the station; the suit was uncomfortably tight at the top and luxuriously loose around her hips, but at least she could breathe.

At Freed's request, she left the lens cap off the camera in the laboratory, and uncovered four external cameras before she clipped the wires that bound the *Caduceus* to the space station.

Since her maneuvering fuel gauge read zero, she decided not to use her jets to separate from the station. Instead, with her hands braced against the frame of her open hatch, she pushed against the truss as hard as she could with both feet and held on. Slowly, Space Station Freedom retreated away from her.

Sealed once again in the *Caduceus*, she waited for orbital mechanics to move her well away from the station. She was frugal with her fuel, allowing a wide deadband as she aligned her sight with the horizon. With their last gasp, her maneuvering rockets imparted a slow rotation to the *Caduceus*. She was pleased to see the spot she had picked on Earth's horizon orbiting very close to the center of her reticle.

Her fingers' shaking was visible even through her glove when she uncovered the switch which might spell her doom. She struggled against a suicidal impulse to just push the damn thing and get it over with. The ground team had worked out landmarks for her, and Freed had provided her with guide stars. She chewed her lips and sucked on her drinking tube, anything to get through the waiting.

Australia came by. Nobody knew of anyone still alive there. New Guinea, confirmed dead. The Solomon Islands, maybe some hope among the primitive, isolated populations.

It was time. She tried her maneuvering rockets. No response; her fuel was gone. Bailey waited for her guide stars to align with the proper circles on her reticle, and pushed the button.

Her seat pushed hard against her back. A solid rocket pack at the back of the *Caduceus* slowed her orbital velocity until her trajectory intersected Earth's atmosphere. The moment the pressure on her back let up, she felt a bump—the rocket pack separating. She was committed to reentry now, in a tiny sphere with no wings, no landing rockets, and absolutely no control.

Her heart pounding, she rode through the fireball of atmospheric entry. She looked up from the bottom of a well of orange flame, watching her spacecraft's ablative heat shield burn away. With its weight loaded toward the back, *Caduceus* weathercocked into the fiery wind, spinning as air friction slowed her velocity. Her suit became a demon, continuously finding new tender spots to

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bruise and chafe as it violently tossed her back and forth. Thankful that there was no one to hear her, she willfully screamed, again and again until she achieved a catharsis which washed out her fear.

There was a quiet period as she fell, watching her altimeter. More sophisticated spacecraft would have used explosive bolts for the hatch; she had a wrench—the same wrench she had used to break into the space station. At a hundred thousand feet, she released the last bolt holding the front hatch in place and kicked the mechanism away. It fluttered out and down, falling faster than the *Caduceus*.

At forty thousand feet, she stood up on her seat and grasped the edges of her open hatch. *Hot!* Her hands reflexively snatched away, fingers smarting from the heat transmitted through her gloves.

Bless the Russians and their paranoia, she thought. *If it hadn't been for them, I wouldn't have even this chance.* She fondly recalled the story Freed had told her about the Russians. In the early days of spaceflight, they were faced with a situation almost identical to hers—they didn't have a way to slow down their spacecraft for landing. Their solution was simple; for the first two flights at least, their space travelers donned parachutes and jumped out of the ship on the way down. Ever since, all their spacecraft had secretly carried parachutes for the crew. When Russia sold the tiny Soyuz capsules to NASA for emergency crew return vehicles on Space Station Freedom, no one had thought to leave out the parachutes. *And bless Freed for remembering it!*

With a firm grip on the interior bulkheads, she carefully aligned herself with the open hatch and emulated those first cosmonauts by bailing out, pushing against her couch to leap upward away from the doomed *Caduceus*.

Wind grabbed her and threw her away from the spacecraft. The world tumbled out of control. The bitter cold of the stratosphere penetrated her suit, sucking heat from her body. Glimpses of the surface flashed past. At least she could see land below. Without a lifeboat, a water landing would be fatal.

She didn't want to release her grip on the precious package of data strapped to her suit, but she had to. Otherwise, she would never be able to stop her tumble. The makeshift straps holding the data package would just have to work. To her relief, the package stayed in place when she spread out her arms and legs, but then the cold hit her; she rolled into a ball to combat it, and started tumbling again. Mounting dizziness forced her to move. With her arms free, her body shuddered uncontrollably in the onslaught of frigid air. At least the data package protected her chest. Working the air currents, she slowly gained control of her attitude. She was falling with hands and feet outstretched, fearfully staring down at the landscape below.

Denser air slowed her descent. Sensible gravity built up until she was lying against her suit, thankfully warmer now in the lower regions of

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the troposphere.

She had timed her return to Earth so she would come down somewhere in the New Mexico desert, but below her lush green vegetation peeked between the clouds. If the body of water to the south was the Gulf of Mexico, she was more than a thousand miles downrange from her intended landing zone, more than a thousand miles from the recovery team. She was headed straight for the Louisiana swamp land, an area long abandoned by humans, given over to the terrible plague.

Two miles above the ground, she pulled her breathing line from the oxygen bottle, leaving her suit fan's intake directly exposed to the outside. Moving her arms induced another tumble. Cold, filtered air assaulted her face.

Clouds rushed toward her. For a moment the world was gray, then her face plate sparkled with trickles of water. She wiped the water away with her glove, and then hastily recovered control over her body attitude.

With a silent prayer, she pulled her rip cord. Her parachute rustled and snapped open, abruptly yanking her upright. She cursed, smarting from a most impolite blow from her suit when it slammed into her. But the glorious sight of the parafoil canopy above her washed out all thoughts of her discomfort. She laughed aloud, savoring the thrill of floating over the prettiest scenery the flatlands had to offer.

At two thousand feet, the air was warmer. After a week and a half of breathing bottled oxygen, her nose eagerly sought the few aromatic molecules which got through her filter. She inhaled the scent of decaying vegetation, vague fishy odors, pollen—the scent of life. It seemed that she could fly forever, borne along by her gossamer parafoil.

Too soon, though, the greensward below began to resolve into individual trees and clumps of bushes scattered among sparkling ponds and streams. It was time to pick a landing spot. No matter where, as long as it was flat; the plague was everywhere in Louisiana.

She experimented with her cords, reciting the drill Freed had put her through. "Pull down on the right, go that way. Pull on the left and swing back around. Be careful not to start a pendulum swing." She selected an area of dark green and steered toward it. It looked solid enough, but—

"Trees!" She screamed to no one but herself. "Move left! No! Right! Swinging out too far! Spill air! Get below it!"

Wham!

As he had done each evening for the past three months, Lloyd Fletcher settled his infant son down for the night and crawled into bed. He worked hard these days, getting up early to fish and spending the afternoons and evenings at his sewing machine. The work helped keep his mind off Bailey, and how he missed her. But late at night, there was no protection from his own memories, from his own mind reminding him of her. Each night, he hugged her pillow

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against him and wept quietly until sleep overcame him.

This night, however, he was awakened by someone pulling the pillow away from him in the dark. The touch of soft cotton was replaced by warm skin against his, and he felt arms and legs enfolding him. Soft lips pressed against his. Unbelieving, his hands traced the familiar curves he had thought he would never touch again. He returned the kiss, hoping it wasn't another dream.

"Bailey?" he finally asked. "BAILEY? But how—"

"Were you expecting someone else?" A merry lilt broke through her husky voice.

"No, there's no one else."

"I know," she said. "I stopped by Ozzie's on my way here to give him the pictures. While he was shooting me full of stuff—be careful of my backside; I feel like a pin cushion—he brought me up to date on what's been going on around here. I borrowed his car and hurried home as soon as he would let me go."

"But where have you been? We waited in Texas, and sent out search teams. They found the wreckage of the *Caduceus,* but no sign of you or the data. The team thought maybe somebody got there ahead of them, but nobody lives within a hundred miles of where you crashed."

He realized he was babbling, but couldn't stop. The enigma of Bailey's disappearance had dominated his thoughts since the day they found the *Caduceus.*

"Christie thought you might have survived the landing somehow, but they figured if you did, you died of the plague somewhere in Louisiana or Mississippi. I didn't know what to do, so I brought Max back up here. The desert is no place for a boy to grow up; he has a better chance here."

She laughed, a happy chuckle. He felt her nose pushing against his jaw, politely urging him to shut up. "No, I didn't catch the virus," she said. "There was nothing left down there to incubate the disease. Ozzie was happy to hear that. It confirmed his data on how long the virus can survive in its crystalline state. Instead I broke my leg falling out of a cypress tree into the Atchafalaya swamp. That's why it took me so long to get home. I would have called you, but I was already in Idaho before I ran across somebody who knew somebody who had a ham radio. I guess I just wanted to keep moving, and avoided towns and people as much as I could. When I finally did get word of a radio nearby, I had to choose between walking ten miles to ask to use it, or hitching an immediate ride to Gold Bar."

"Are you all right?"

"Good as new. Ozzie x-rayed my leg, simple fracture, nicely healed. He even complimented me on the job I did with splinting it."

He switched on a lamp on the bedside table.

"Which leg?"

"The left one. Thigh bone."

"It looks good," he said, investigating the topic of conversation with his fingertips. "All of you looks good! If I could only tell you what it means to

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me to have you back—"

She put a finger to his lips and whispered, "Show me."

In the middle of the night, when they were too exhausted to go on but too wound up for sleep, she finally asked about her son.

"Max is doing great, sleeping through the night this past week," he said. "He's been crawling all over the place, and he's started jabbering, trying to talk instead of just crying. Somehow though, I can tell he misses his mother. He needs you."

"I've missed him, too. He looks good, though, even cuter now, from what I could tell. There's not much light in his room. I would have turned on a lamp, but I didn't want to wake him. So I just stared at him in the dark."

"You checked on him before you woke me up?"

"Yes I did," she said. "Would you expect anything else?"

"No, of course not."

"Well, Max will have his mother back from now on. That was the clincher Ozzie used to talk me into letting someone else make the next trip."

"Next trip?"

"I left a friend in distress up there, and Ozzie says if we can get the laboratory working full time again, we'll never have another plague. They're going to do it again!"

In the late autumn of 2026, teams of hunters crept stealthily through the North Cascade Mountains. Instead of bullets, their guns carried hypodermic syringes loaded with drugs to combat the virus. There was not much they could do for the small rodents, though they hoped they had inoculated enough of those caught in live traps to save the species. Their targets were the large mammals of the forest—deer, elk, sheep, some wolves, and even an occasional mountain lion. There weren't enough people left on Earth to manage breeding herds, so they settled for saving the animals where they found them and trusted to nature for the rest. A few birds flitted through the trees, their calls again challenging the croaks of amphibians and the chirps of crickets as they feasted on the abundant insect life.

Ozzie's short-wave radio station broadcast on six bands twenty-four hours a day, an endless loop replaying all they had learned about the virus and how to formulate drugs to combat it. He spent two hours each evening in his radio shack, talking with others around the globe. At first, all they talked about was the virus and the drugs. But now the people of Earth exchanged plans for new towns and farms, new building projects, even new scientific laboratories.

After decades of nothing but despair, they were beginning to exchange messages of hope. ■

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Robert M. Zubrin &
Christopher P. McKay

TERRAFORMING MARS

INTRODUCTION

Not so long ago, the subject of human voyages to the Moon was the domain of science fiction. Today, lunar expeditions are a subject for historians, and manned Mars exploration the province of hard-headed engineers. A great many people now accept the idea that, in the not too distant future, humanity will have a permanently staffed base on Mars, or even a number of large settlements. However, the prospect of drastically changing the planet's temperature and atmosphere towards more Earth-like conditions, in other words "terraforming" Mars, still seems to the large majority to be either sheer fantasy or at best a technological challenge for the far distant future.

But is this pessimistic point of view correct? Despite the fact that Mars today is a cold, dry, and probably lifeless planet, it has all the elements required to support life: water, carbon and oxygen (as carbon dioxide), and nitrogen. The physical aspects of Mars—its gravity, rotation rate and axial tilt—are close enough to those of Earth to be acceptable and it is not too far from the Sun to be made inhabitable.

In fact, recent computational studies utilizing climate models suggest that it could be possible to make Mars habitable with foreseeable technology. The essence of the situation is that while Mars's CO_2 atmosphere has only about 1% the pressure of the Earth's at sea level, it is believed that there are reserves of CO_2 frozen in the south polar cap and adsorbed within the soil sufficient to thicken the atmosphere to the point where its pressure would be about 30% that of Earth. The way to get this gas to emerge is to heat the planet. In fact, the warming and cooling of Mars that occurs each Martian year as the planet cycles between its nearest and furthest positions from the Sun, in its slightly elliptical orbit, cause the atmospheric pressure on Mars to vary by plus or minus 25% compared to its average value on a seasonal basis.

We cannot, of course, move Mars to a warmer orbit. However we do know another way to heat a planet, through an artificially induced greenhouse effect that traps the Sun's heat

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within the atmosphere. Such an atmospheric greenhouse could be created on Mars in at least three different ways. One way would be to set up factories on Mars to produce very powerful artificial greenhouse gasses such as halocarbons ("CFC's") and release them into the atmosphere. Another way would be to use orbital mirrors or other large-scale power sources to warm selected areas of the planet, such as the south polar cap, to release large reservoirs of the native greenhouse gas, CO_2, which may be trapped there in frozen or adsorbed form. Finally natural greenhouse gasses more powerful than CO_2 (but much less so than halocarbons) such as ammonia or methane could be imported to Mars in large quantities if asteroidal objects rich with such volatiles in frozen form should prove to exist in the outer Solar System.

Each of these methods of planetary warming would be enhanced by large amounts of CO_2 from the polar cap and from the soil that would be released as a result of the induced temperature rise. This CO_2 would add massively to the greenhouse effect being created directly, speeding and multiplying the warming process.

The Mars atmosphere/regolith greenhouse effect system is thus one with a built-in positive feedback. The warmer it gets, the thicker the atmosphere becomes; and the thicker the atmosphere becomes the warmer it gets. In the sections below, we'll show how this system can be modeled, and present the results of our calculations using such a model. Our results give very strong support to the belief that humans will be able to effect radical improvements in the habitability of the Martian environment in the course of the 21st century.

EQUATIONS FOR MODELING THE MARTIAN SYSTEM

An equation for estimating the mean temperature on the surface of Mars as a function of the CO_2 atmospheric pressure and the solar constant is given by McKay and Davis[1] as:

$$T_{mean} = 213.5(S^{0.25}) + 20(1 + S)P^{0.5} \quad (1)$$

where T_{mean} is the mean planetary temperature in Kelvins, S is the amount of solar output, where that of the present day Sun = 1, and P is the atmospheric pressure at Mars's mean surface elevation, given in bars. (One bar is what flatlanders believe is normal atmospheric pressure, 14.7 pounds per square inch. Since people living in the fetid swamps near such major capitals as Washington, London, and Paris are influential in such things, this bizarre unit has become a standard.)

Since the atmosphere is an effective means of heat transport from the equator to the pole, we estimate:

$$T_{pole} = T_{mean} - 75(S^{0.25})/(1 + 5P) \quad (2)$$

We further assume, based upon a rough approximation to observed data, that:

$$T_{max} = T_{equator} = 1.1T_{mean} \quad (3)$$

and that the global temperature distribution is given by:

$$T(\Theta) = T_{max} = (T_{max} - T_{pole})\sin^{1.5}\Theta \quad (4)$$

where Θ is the latitude (north or south).

Equations (1) through (4) give the

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temperature on Mars as a function of CO_2 pressure. However, as mentioned above, the CO_2 pressure on Mars is itself a function of the temperature. There are three reservoirs of CO_2 on Mars, the atmosphere, the dry ice in the polar caps, and gas adsorbed in the soil. The interaction of the polar cap reservoirs with the atmosphere is well understood and is given simply by the relationship between the vapor pressure of CO_2 and the temperature at the poles. This is given by the vapor pressure curve for CO_2, which is approximated by:

$$P = 1.23 \times 10^7\{\exp(-3170/T_{pole})\} \quad (5)$$

So long as there is CO_2 in both the atmosphere and the cap, equation (5) gives an exact answer to what the CO_2 atmospheric pressure will be as a function of polar temperature. However if the polar temperature should rise to a point where the vapor pressure is much greater than that which can be produced by the mass in the cap reservoir (between 50 and 100 mb) then the cap will disappear and the atmosphere will be regulated by the soil reservoir.

The relationship between the soil reservoir, the atmosphere and the temperature is not known with precision. An educated guess is given in parametric form in reference 1 as:

$$P = \{CM_a\exp(T/T_d)\}^{3.64} \quad (6)$$

where M_a is the amount of gas adsorbed in the soil in bar, C is a constant set so that equation (6) will reflect known Martian conditions, and T_d is the characteristic energy required for release of gas from the soil (the "desorption temperature"). Equation (6) is essentially a variation of a well-known law for the change in chemical equilibrium with temperature, and so there is fair confidence that its general form is correct. However, the value of T_d is unknown and probably will remain so until after human exploration of Mars. While we don't know what the right value for T_d is, we can bracket the problem by varying T_d from 15 to 40 K (the lower the value of T_d the easier things are for prospective terraformers.) Then we use the global temperature distribution given by equation (4) to integrate equation (6) over the surface of the planet to give us a global "soil pressure." This gives a reasonably accurate quasi 2-dimensional view of the atmosphere/regolith equilibrium problem in which most of the adsorbed CO_2 is distributed to the planet's colder regions. Thus in our model, regional (in the sense of latitude) temperature changes, especially in the near-polar regions, can have as important a bearing on the atmosphere/regolith interaction as changes in the planet's mean temperature.

RESULTS OF CALCULATIONS

In Fig. 1 we see the results of our model when applied to the situation at Mars's south polar cap, where it is believed that enough CO_2 may be held frozen as dry ice to give Mars an atmosphere on the order of 50 to 100 mbar. We have plotted the polar temperature as a function of the pressure, in accord with equations (1) and (2), and the vapor pressure as a function of the polar temperature, in accord with equation (5). There are two equilibrium points, labeled A and B,

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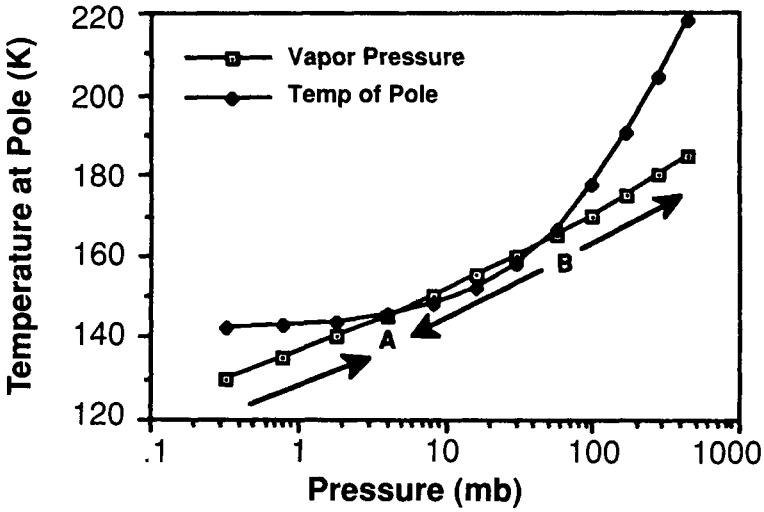

Figure 1: Mars polar cap/atmosphere dynamics. Current equilibrium is at point A. Raising polar temperatures by 4K would drive equilibria A and B together, causing runaway heating that would lead to the elimination of the cap.

where the values of P and T are mutually consistent. However A is a stable equilibrium, while B is unstable. This can be seen by examining the dynamics of the system wherever the two curves do not coincide. Whenever the temperature curve lies above the vapor pressure curve, the system will move to the right, i.e. towards increased temperature and pressure; this would represent a runaway greenhouse effect. Whenever the pressure curve lies above the temperature curve, the system will move to the left, i.e. temperatures and pressure will both drop in a runaway ice-box effect. Mars today is at point A, with 6 mbar of pressure and a temperature of about 147 K at the pole.

Now consider what would happen if someone artificially increased the temperature of the Martian pole by several degrees K. As the temperature is increased, points A and B would move towards each other until they met. If the temperature increase were 4 K, the temperature curve would be moved upwards on the graph sufficiently so that it would lie above the vapor pressure curve everywhere. The result would be a runaway greenhouse effect that would cause the entire pole to evaporate, perhaps in less than a decade. Once the pressure and temperature have moved past the current location point B, Mars will be

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in a runaway greenhouse condition even without artificial heating, so if later the heating activity were discontinued the atmosphere would remain in place.

As the polar cap evaporates, the dynamics of the greenhouse effect caused by the reserves of CO_2 held in the Martian soil come into play. These reserves exist primarily in the high latitude regions, and by themselves are estimated to be enough to give Mars a 400 mbar atmosphere. We can't get them all out, however, because as they are forced out of the ground by warming, the soil becomes an increasingly effective "dry sponge" acting to hold them back. The dynamics of this system are shown in fig. 2, in which we assume T_d = 20, current polar reserves of 100 mb, and regolith reserves of 394 mb, and graph the pressure on the planet as a function of the regolith temperature, T_{reg}, where T_{reg} is the average of the planet's temperature with different regions weighted in accordance with how much adsorbed gas they can hold at their own local temperature.

Since T_{reg} is a function of the temperature distribution and T_{mean}, it is ultimately just a function of the pressure, and thus $T_{reg}(P)$ can also be graphed. The result is a set of T(P) curves and P(T) curves, whose crossing points reflect stable or unstable equilibrium, just as in the case of the polar cap analysis.

It can be seen in fig. 2 that the at-

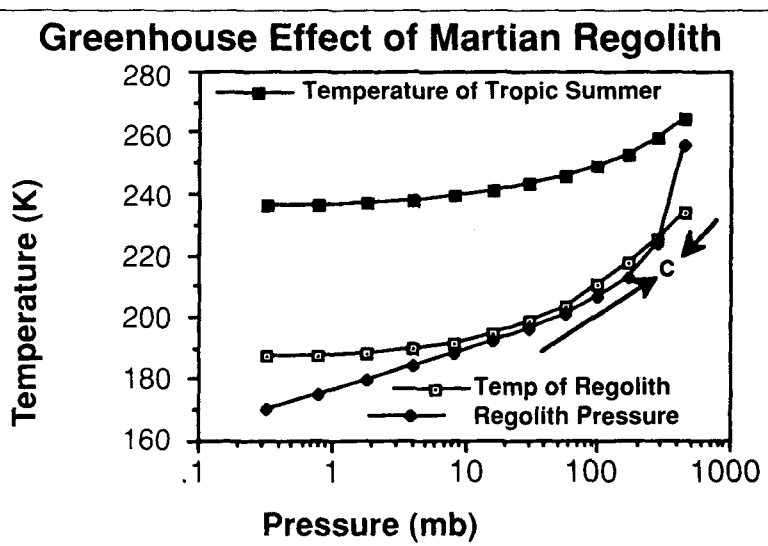

Figure 2: Mars regolith/atmosphere dynamics under conditions of T_d=20 with a volatile inventory of 500 mb of CO_2.

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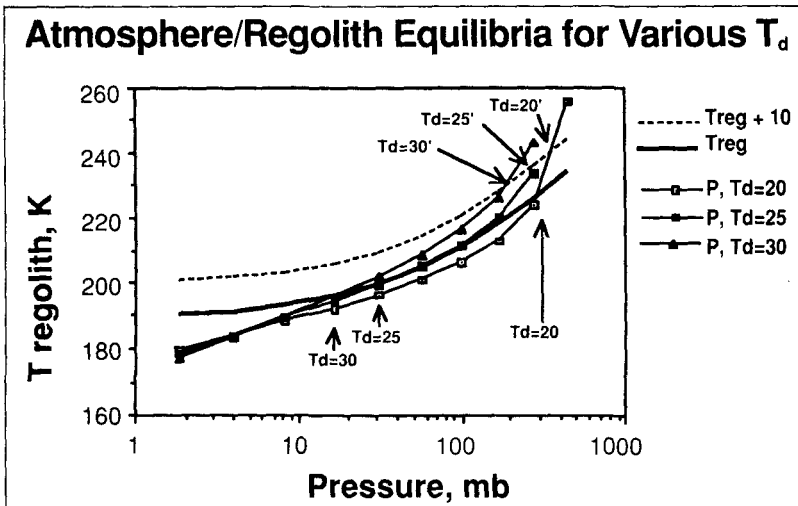

Figure 3: An induced 10 K rise in regolith temperature can counter effect of T_d variations. Data shown assumes a planetary volatile inventory of 500 mb CO_2.

mosphere soil system under the chosen assumption of T_d = 20 K has only 1 equilibrium point, which is stable, and which will be overrun by the pressure generated by the vaporized polar cap. Thus, by the time the process is brought to a halt, an atmosphere with a total pressure of about 300 mbar, or 4.4 pounds per square inch, can be brought into being. Also shown in fig. 2 is the day-night average temperature that will result in Mars's tropical regions (T_{max}) during summertime. It can be seen that the 273 K freezing point of water will be approached. With the addition of modest ongoing artificial greenhouse efforts, it can be exceeded.

The assumption of T_d = 20 is optimistic, however, and the location of the equilibrium convergence point (point C in fig. 2) is very sensitive to the value chosen for T_d. In fig. 3 we show what happens if values of T_d = 25 and T_d = 30 are assumed. In these cases, the convergence point moves from 300 mb at T_d = 20 to 31 and 16 mb for T_d = 25 and T_d = 30 respectively. (The value of the T_{reg} curve in fig. 3 was calculated under the assumption of T_d = 25; it varies from this value by a degree or two for T_d = 20 or 30.) Such extraordinary sensitivity of the final condition to the unknown value of T_d may appear at first glance to put the entire viability of the terraforming concept at risk. However in fig. 3 we also show (dotted line) the situation if artificial greenhouse methods are employed

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to maintain T_{reg} at a temperature 10 K above those produced by the CO_2 outgassing itself. It can be seen that drastic improvements in the final T and P values are effected for the T_d = 25 and 30 cases, with all three cases converging upon final states with Mars possessing atmospheres with several hundred millibars pressure.

In figs. 4, 5, 6, and 7 we show the convergence condition pressure and maximum seasonal average temperature in the Martian tropics resulting on either a "poor" Mars, possessing a total supply of 500 mb of CO_2 (50 mb of CO_2 in the polar cap and 444 mb in the regolith), or a "rich" Mars possessing 1000 mb of CO_2 (100 mb in the polar cap and 894 mb in the regolith). Different curves are shown under the assumptions that either no sustained greenhouse effort is mounted after the initial polar cap release, or that continued efforts are employed to maintain the planet's mean temperature a ΔT of 5, 10, or 20 degrees above the value produced by the CO_2 atmosphere alone. It can be seen that if a sustained effort is mounted to keep an artificial ΔT of 20 degrees in place, then a tangible atmosphere and acceptable pressures can be produced even if T_d has a pessimistic value of 40 K.

The important conclusion to be drawn from this analysis is that while the final conditions on a terraformed Mars may be highly sensitive to the currently unknown value of the regolith's outgassing energy, T_d, they are even more sensitive to the level of sustained artificially induced green-

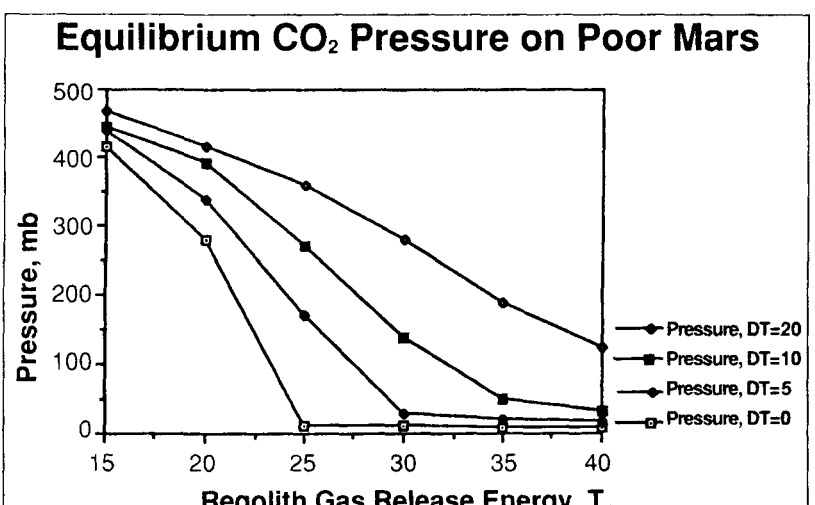

Figure 4: Equilibrium pressure reached on Mars with a planetary volatile inventory of 500 mb CO_2 after 50 mb polar cap has been evaporated. DT (ΔT in text) is artificially imposed sustained temperature rise.

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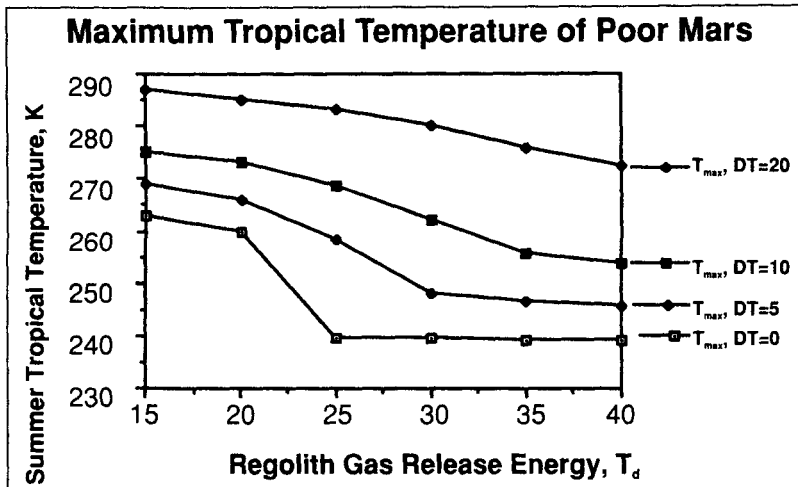

Figure 5: Equilibrium maximum seasonal (diurnal average) temperature reached on Mars with a planetary volatile inventory of 500 mb CO_2 after 50 mb polar cap has been evaporated.

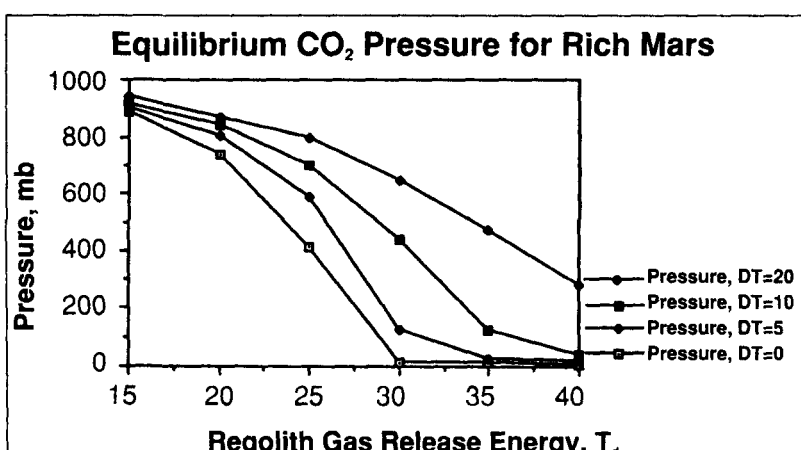

Figure 6: Equilibrium pressure reached on Mars with a planetary volatile inventory of 1000 mb CO_2 after 100 mb polar cap has been evaporated.

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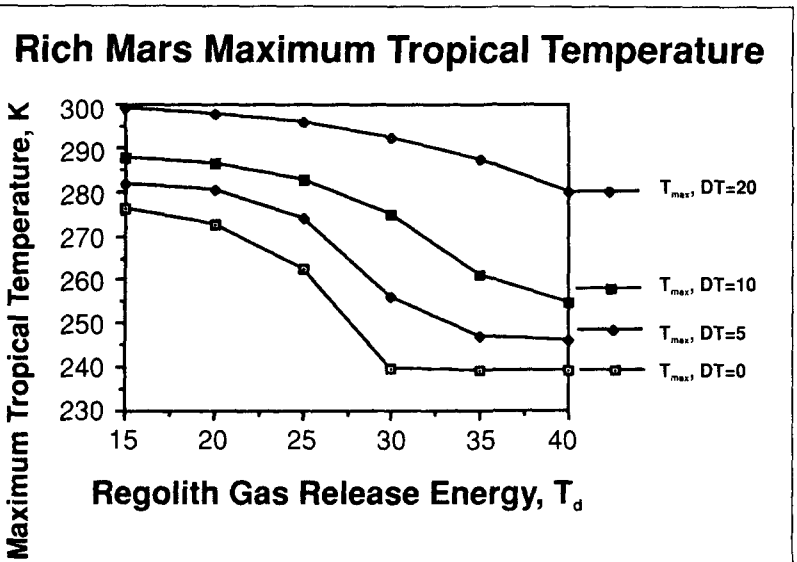

Figure 7: Equilibrium maximum seasonal temperature (diurnal average) reached on Mars with a planetary volatile inventory of 1000 mb CO_2 after 100 mb polar cap has been evaporated.

housing, ΔT. Put simply, the final conditions of the atmosphere/regolith system on a terraformed Mars are *controllable*.

Once significant regions of Mars rise above the freezing point of water on at least a seasonal basis, the large amounts of water frozen into the soil as permafrost would begin to melt, and eventually flow out into the dry riverbeds of Mars. Water vapor is also a very effective greenhouse gas, and since the vapor pressure of water on Mars would rise enormously under such circumstances, the reappearance of liquid water on the Martian surface would add to the avalanche of self-accelerating effects all contributing to the rapid warming of Mars. The seasonal availability of liquid water is also the key factor in allowing the establishment of natural ecosystems on the surface of Mars.

The dynamics of the regolith gas-release process are only approximately understood, and the total available reserves of CO_2 won't be known until human explorers journey to Mars to make a detailed assessment, so these results must be regarded as approximate and uncertain. Nevertheless, it is clear that the positive feedback generated by the Martian CO_2 greenhouse system greatly reduces the amount of engineering effort that would otherwise be re-

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quired to transform the Red Planet. In fact, since the amount of a greenhouse gas needed to heat a planet is roughly proportional to the square of the temperature change required, driving Mars into a runaway greenhouse with an artificial 5 K temperature rise only requires about 1% the engineering effort that would be needed if the entire 50 K rise had to be engineered by brute force. The question we shall now examine is how such a 5 K global temperature rise could be induced.

METHODS OF ACCOMPLISHING GLOBAL WARMING ON MARS

The three most promising options for inducing the required temperature rise to produce a runaway greenhouse on Mars appear to be the use of orbital mirrors to change the heat balance of the south polar cap (thereby causing its CO_2 reservoir to vaporize), the importation of ammonia rich objects from the outer Solar System, and the production of artificial halocarbon ("CFC") gases on the Martian surface. We'll look at each of these in turn. It may be, however, that synergistic[3] combination of several such methods may yield better results than any one of them used alone.

ORBITING MIRRORS

While the production of a space-based sunlight-reflecting device capable of warming the entire surface of Mars to terrestrial temperatures is theoretically possible[5], the engineering challenges involved in such a task place such a project well outside the technological horizon of this article. A much more practical idea would be to construct a more modest mirror capable of warming a limited area of Mars by a few degrees. As shown by the data in fig. 1, a 5 degree K temperature rise imposed at the pole should be sufficient to cause the evaporation of the CO_2 reservoir in the south polar cap. Based upon the total amount of solar energy required to raise the black-body temperature of a given area a certain number of degrees above the polar value of 150 K, it turns out that a space-based mirror with a radius of 125 km could reflect enough sunlight to raise the entire area south of 70 degrees south latitude by 5 K. If made of solar sail type aluminized Mylar material with a density of 4 tonnes/km^2, such a sail would have a mass of 200,000 tonnes. Many ships of this size are currently sailing the Earth's oceans. Thus, while this is too large to consider launching from Earth, if space-based manufacturing techniques are available its construction in space out of asteroidal or Martian moon material is a serious option. The total amount of energy required to process the materials for such a reflector would be about 120 MWe-years, which could be readily provided by a set of 5 MWe nuclear reactors such as are now being considered for use in piloted nuclear electric spacecraft. Interestingly, if stationed near Mars, such a device would not have to orbit the planet. Rather, solar light pressure could be made to balance the planet's gravity, allowing it to hover as a "statite"[6] with its power output trained constantly at the polar region.

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For the sail density assumed, the required operating altitude would be 214,000 km. The statite reflector concept and the required mirror size to produce a given polar temperature rise is shown in figs. 8 and 9.

If the value of T_d is lower than 20 K, then the release of the polar CO_2 reserves by themselves could be enough to trigger the release of the regolith's reserves in a runaway greenhouse effect. If however, as seems probable, T_d is greater than 20 K, then either the importation or pro-

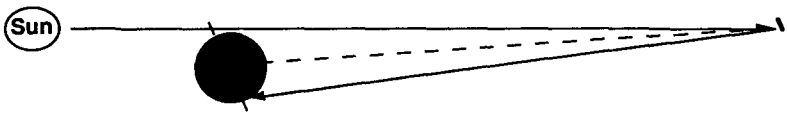

Figure 8: Solar sails of 4 tonnes/km^2 density can be held stationary above Mars by light pressure at an altitude of 214,000 km. Wasting a small amount of light allows shadowing to be avoided.

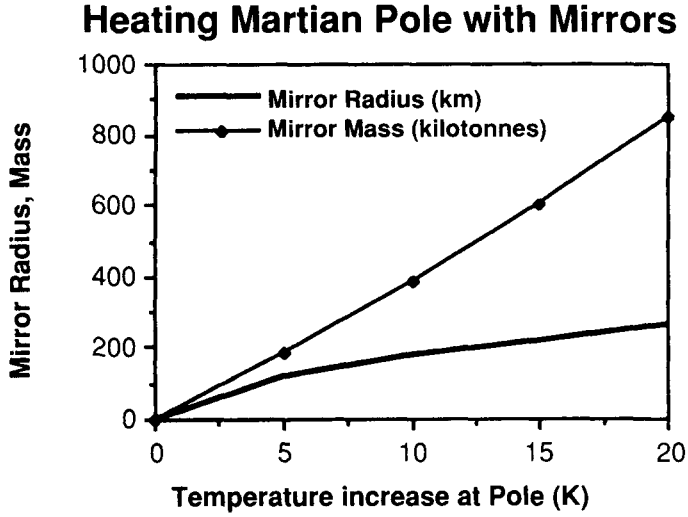

Figure 9: Solar sail mirrors with radii on the order of 100 km and masses of 200,000 tonnes can produce the 5K temperature rise required to vaporize the CO_2 in Mars's south polar cap. It may be possible to construct such mirrors in space.

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duction of strong greenhouse gases will be required to force a global temperature rise sufficient to create a tangible atmospheric pressure on Mars.

MOVING AMMONIA ASTEROIDS

Ammonia is a powerful greenhouse gas, and it is possible that nature has stockpiled large amounts of it in frozen form on asteroidal-sized objects orbiting in the outer Solar System. If moving material from such objects to Mars is envisioned, then such orbits would be quite convenient, because strange as it may seem, it is easier to move an asteroid from the outer Solar System to Mars than it is to do so from the Main Belt or any other inner Solar System orbit. This odd result follows from the laws of orbital mechanics, which cause an object farther away from the Sun to orbit it slower than one that is closer in. Because an object in the outer Solar System moves slower, it takes a smaller ΔV to change its orbit from a circular to an ellipse. Furthermore, the orbit does not have to be so elliptical that it stretches from Mars to the outer Solar System; it is sufficient to distort the object's orbit so that it intersects the path of a major planet, after which a gravity assist can do the rest. The results are shown in fig. 10. It can be seen that moving an asteroid positioned in a circular orbit at 25 AU, by

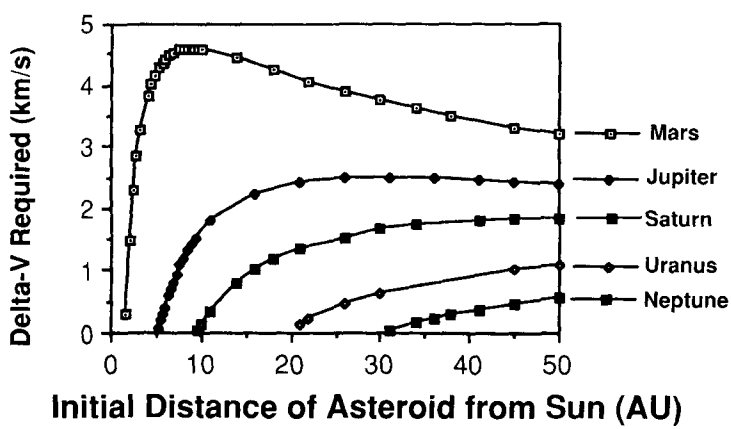

Figure 10: Using gravity assists, the ΔV required to propel an outer Solar System asteroid onto a collision course with Mars can be less than 0.5 km/s. Such "falling" objects can release much more energy upon impact than was required to set them in motion.

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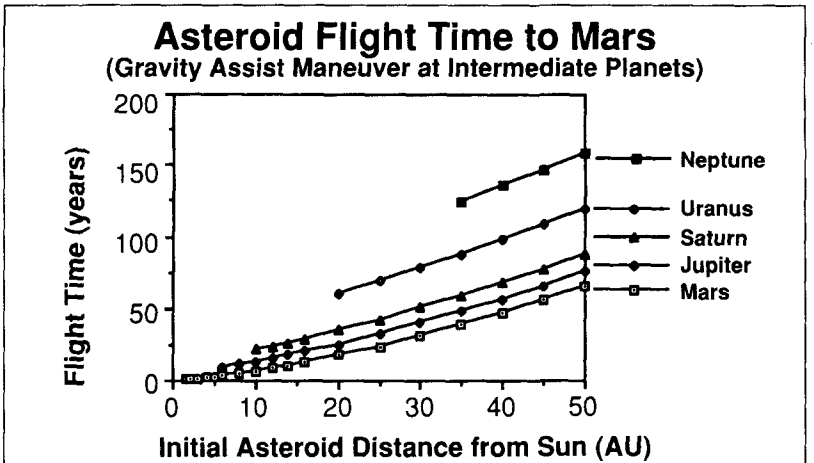

Figure 11: Ballistic flight times from the outer Solar System to Mars are typically between 25 and 50 years.

way of a Uranus gravity assist to Mars, requires a ΔV of only 0.3 km/s, compared to a 3.0 km/s ΔV to move an asteroid directly to Mars from a 2.7 AU position in the Main Belt. The time of flight required for such transfers is shown in fig. 11.

Now we don't know for sure if there are numerous asteroid-size objects in the outer Solar System, but there is no reason to believe that there aren't. As of this writing, only one is known, but that one, Chiron, orbiting between Saturn and Uranus, is rather large (180 km diameter), and it may be expected that a lot of small objects can be found for every big one. In all probability, the outer Solar System contains thousands of asteroids that we have yet to discover because they shine so dimly compared to those in the Main Belt (The brightness of an asteroid as seen from Earth is inversely proportional to the fourth power of its distance from the Sun.). Furthermore, because water, ammonia, and other volatiles freeze so completely in the outer Solar System, it is likely that the asteroids to be found beyond Saturn are largely composed of frozen gases (such appears to be the case for Chiron). This makes it possible for us to move them.

Consider an asteroid made of frozen ammonia with a mass of 10 billion tonnes orbiting the Sun at a distance of 12 AU. Such an object, if spherical, would have a diameter of about 2.6 km, and changing its orbit to intersect Saturn's (where it could get a trans-Mars gravity assist) would require a ΔV of 0.3 km/s. If a quartet of 5000 MW nuclear thermal rocket (NTR) engines powered by either fission or fusion were used to heat some of its ammonia up to 2200 K (5000 MW fission NTRs operating at

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2500 K were tested in the 1960s), they would produce an exhaust velocity of 4 km/s, which would allow them to move the asteroid onto its required course using only 8% of its material as propellant. Ten years of steady thrusting would be required, followed by about a 20-year coast to impact. When the object hits Mars, the energy released would be about 10 TW-years, enough to melt 1 trillion tonnes of water (a lake 140 km on a side and 50 meters deep). In addition, the ammonia released by a single such object would raise the planet's temperature by about 3 degrees Kelvin and form a shield that would effectively mask the planet's surface from ultraviolet radiation. As further missions proceeded, the planet's temperature could be increased globally in accord with the data shown in fig. 12. Forty such missions would double the nitrogen content of Mars's atmosphere by direct importation, and could produce much more if some of the asteroids were targeted to hit beds of nitrates, which they would volatilize into nitrogen and oxygen upon impact. If one such mission were launched per year, within half a century or so most of Mars would have a temperate climate, and enough water would have been melted to cover a quarter of the planet with a layer of water 1 m deep.

While attractive in a number of respects, the feasibility of the asteroidal impact concept is uncertain because of the lack of data on outer Solar System ammonia objects. Moreover, if T_d is greater than 20 K, a sustained greenhousing effort will be required. As the characteristic lifetime of an ammonia molecule on Mars is likely to be less than a century, this means

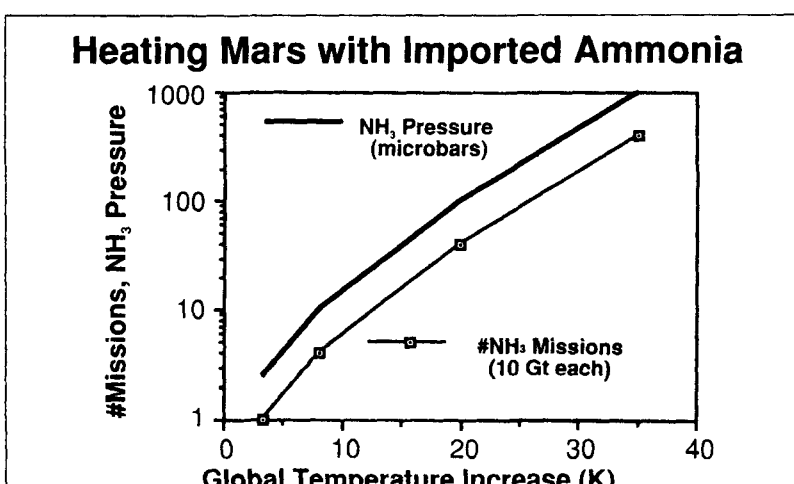

Figure 12: Importing four 10 billion tonne ammonia asteroids to Mars would impose an 8 K temperature rise, which after amplification by CO_2 feedback could create drastic changes in global conditions.

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that even after the temperature is raised, ammonia objects would need to continue to be imported to Mars, albeit at a reduced rate. As each object will hit Mars with an energy yield to about 70,000 1 megaton hydrogen bombs, the continuation of such a program may be incompatible with the objective of making Mars suitable for human settlement.

A possible improvement to the ammonia impact method is suggested by ideas given in reference 4, where it is pointed out that bacteria exist which can metabolize nitrogen and water to produce ammonia. If an initial greenhouse condition were to be created by ammonia object importation, it may be possible that a bacterial ecology could be set up on the planet's surface that would recycle the nitrogen resulting from ammonia photolysis back into the atmosphere as ammonia, thereby maintaining the system without the need for further impacts. Similar schemes might also be feasible for cycling methane, another short-lived natural greenhouse gas which might be imported to the planet.

PRODUCING HALOCARBONS ON MARS

In table 1 we show the amount of halocarbon gases (CFC's) needed in Mars's atmosphere to create a given temperature rise, and the power that would be needed on the Martian surface to produce the required CFC's over a period of 20 years. If the gases have an atmospheric lifetime of 100 years, then approximately one-fifth the power levels shown in the table will be needed to maintain the CFC concentration after it has been built up. For purposes of comparison, a typical nuclear power plant used on Earth today has a power output of about 1000 MW_e and provides enough energy for a medium-sized (Denver) American city. The industrial effort associated with such a power level would be substantial, producing about a trainload of refined material every day and requiring the support of a work crew of several thousand people on the Martian surface. A total project budget of several hundred billion dollars might well be required. Nevertheless, all things considered, such an operation is hardly likely to be beyond the capabilities of the mid-21st century.

Using such an approach, Mars could be transformed from its current dry and frozen state into a warm and slightly moist planet capable of

Table 1: Greenhousing Mars with CFCs

Induced Heating (degrees K)	CFC Pressure (micro-bar)	CFC Production (tonnes/hour)	Power Required (MWe)
5	0.012	263	1315
10	0.04	878	4490
20	0.11	2414	12070
30	0.22	4829	24145
40	0.80	17569	87845

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supporting life in several decades. Humans could not breathe the air of the thus transformed Mars, but they would no longer require space suits and instead could travel freely in the open wearing ordinary clothes and a simple SCUBA type breathing gear. However, because the outside atmospheric pressure will have been raised to human tolerable levels, it will be possible to have large habitable areas for humans under huge domelike inflatable tents containing breathable air. On the other hand, simple hardy plants could thrive in the CO_2 rich outside environment, and spread rapidly across the planet's surface. In the course of centuries, these plants would introduce oxygen into Mars's atmosphere in increasingly breathable quantities, opening up the surface to advanced plants and increasing numbers of animal types. As this occurred, the CO_2 content of the atmosphere would be reduced, which would cause the planet to cool unless artificial greenhouse gases were introduced capable of blocking off those sections of the infrared spectrum previously protected by CO_2. The halocarbon gases employed would also have to be varieties lacking in chlorine, if an ultraviolet shielding ozone layer is to be built up. One good candidate for such a gas would be perfluoromethane, CF_4, which also has the desirable feature of being very long lived (about 10,000 years) in an upper atmosphere. Providing these matters are attended to, however, the day would eventually come when the domed tents would no longer be necessary.

* * *

ACTIVATING THE HYDROSPHERE

The first steps required in the terraforming of Mars, warming the planet and thickening its atmosphere, can be accomplished with surprisingly modest means using *in situ* production of halocarbon gases. However, the oxygen and nitrogen levels in the atmosphere would be too low for many plants, and if left in this condition the planet would remain relatively dry, as the warmer temperatures took centuries to melt Mars's ice and deeply buried permafrost. It is in this, the second phase of terraforming Mars, during which the hydrosphere is activated, the atmosphere made breathable for advanced plants and primitive animals, and the temperature increased further, that either space-based manufacturing of large solar concentrators or human activity in the outer Solar System is likely to assume an important role.

Activating the Martian hydrosphere in a timely fashion will require doing some violence to the planet, and, as discussed above, one way this can be done is with targeted asteroidal impacts. Each such impact releases the energy equivalent of 10 TW-yrs. If Plowshare methods of shock treatment for Mars are desired, then the use of such projectiles is certainly to be preferred to the alternative option[3] of detonation of hundreds of thousands of thermonuclear explosives. After all, even if so much explosive could be manufactured, its use would leave the planet unacceptably radioactive.

The use of orbiting mirrors pro-

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vides an alternative method for hydrosphere activation. For example, if the 125 km radius reflector discussed earlier for use in vaporizing the pole were to concentrate its power on a smaller region, 27 TW would be available to melt lakes or volatilize nitrate beds. This is triple the power available from the impact of a 10 billion tonne asteroid every year, and in all probability would be far more controllable. A single such mirror could drive vast amounts of water out of the permafrost and into the nascent Martian ecosystem very quickly. Thus while the engineering of such mirrors may be somewhat grandiose, the benefits to terraforming, of being able to wield tens of TW of power in a controllable way can hardly be overstated.

OXYGENATING THE PLANET

The most technologically challenging aspect of terraforming Mars will be the creation of sufficient oxygen in the planet's atmosphere to support animal life. While primitive plants can survive in an atmosphere without oxygen, advanced plants require about 1 mb and humans need 120 mb. While Mars may have super-oxides in its soil or nitrates that can be pyrolysed to release oxygen (and nitrogen) gas, the problem is the amount of energy needed: about 2200 TW-years for every mb produced. Similar amounts of energy are required for plants to release oxygen from CO_2. Plants, however, offer the advantage that once established they can propagate themselves. The production of an oxygen atmosphere on Mars thus breaks down into two phases. In the first phase, brute force engineering techniques are employed to produce sufficient oxygen (about 1 mb) to allow advanced plants to propagate across Mars. Assuming there are three 125 km radius space mirrors active in supporting such a program and sufficient supplies of suitable target material on the ground, such a goal could be achieved in about 25 years. At that point, with a temperate climate, a thickened CO_2 atmosphere to supply pressure and greatly reduce the space radiation dose, and a good deal of water in circulation, plants that have been genetically engineered to tolerate Martian soils and to perform photosynthesis at high efficiency could be released together with their bacterial symbiotes. Assuming that global coverage could be achieved in a few decades and that such plants could be engineered to be 1% efficient (rather high, but not unheard of among terrestrial plants) then they would represent an equivalent oxygen-producing power source of about 200 TW. By combining the efforts of such biological systems with perhaps 90 TW of space based reflectors and 10 TW of installed power on the surface (terrestrial civilization today uses about 12 TW), the required 120 mb of oxygen needed to support humans and other advanced animals in the open could be produced in about 900 years. If more powerful artificial energy sources or still more efficient plants were engineered, then this schedule could be accelerated accordingly, a fact which may well prove a driver in bringing such tech-

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nologies into being. It may be noted that thermonuclear fusion power on the scale required for the acceleration of terraforming also represents the key technology for enabling piloted interstellar flight. If terraforming Mars were to produce such a spinoff, then the ultimate result of the project will be to confer upon humanity not only one new world for habitation, but myriads.

CONCLUSION

What we have shown in this article is that within broad tolerances of uncertainty of Martian conditions, that drastic improvements in the life-sustaining characteristics of the environment of the Red Planet may be effected by humans using early to mid-21st century technologies. While our immediate descendants cannot expect to use such near-term methods to "terraform" the planet in the full sense of the word, it at least should be possible to rejuvenate Mars, making it again as receptive to life as it once was. Moreover, in the process of modifying Mars, they are certain to learn much more about how planets really function and evolve, enough perhaps to assure wise management of our native planet.

Beyond such near-term milestones, the tasks associated with full terraforming become more daunting and the technologies required more speculative. Yet who can doubt that if the first steps are taken, that the developments required to complete the job will not follow, for what is ultimately at stake is an infinite universe of habitable worlds.

Seen in such light the task facing our generation—that of exploring Mars and learning enough about the planet and the methods of utilizing its resources to begin to transform it into a habitable planet—could not be more urgent, or more noble. ■

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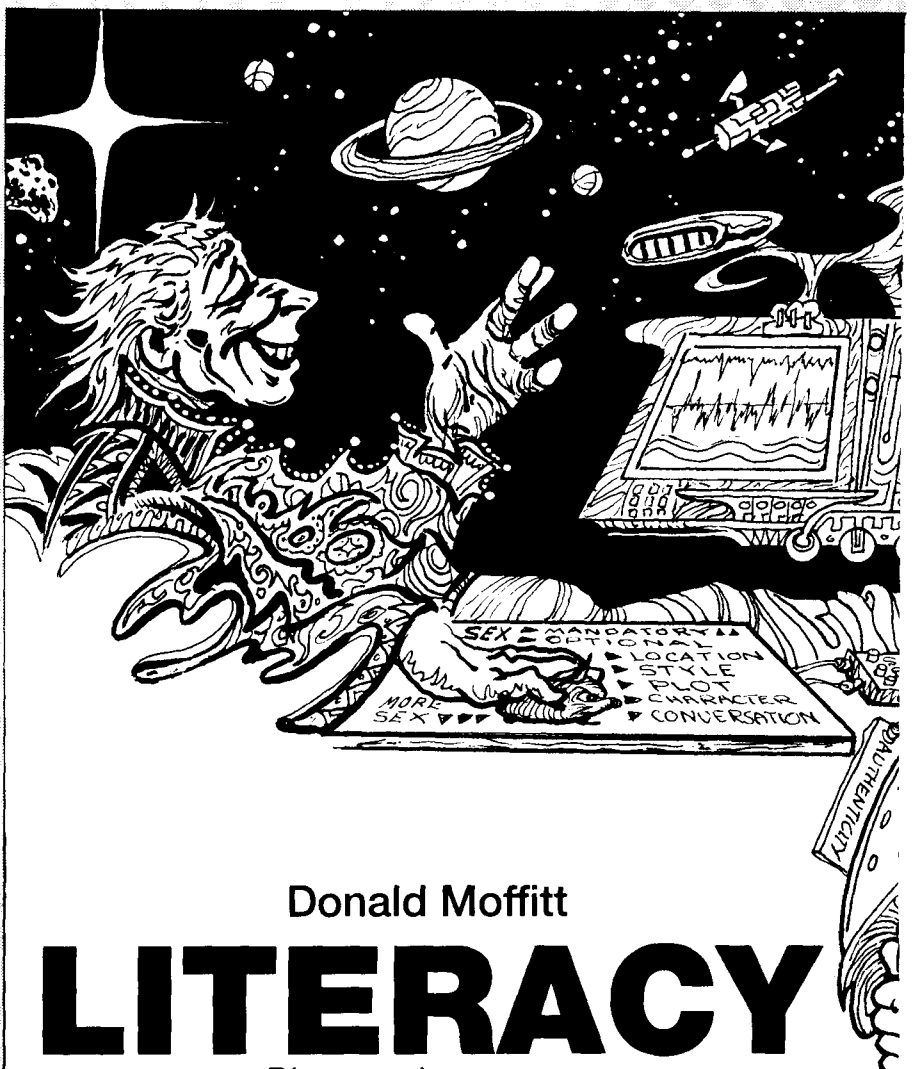

Donald Moffitt

LITERACY

Plus ça change. . . .

Illustration by Kelly Freas

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Shum-il of the city of Kish walked around the market square several times before he was able to work up enough nerve to approach the scribe sitting next to the temple steps. The scribe looked like an important man, and his clients all seemed to be persons of substance, wearing linen skirts and bracelets of copper or gold.

Finally he made up his mind and walked up to the intimidating figure.

"Pardon me, lord," he said. "I'm told that you may send my voice far away, even to another city, so that I may speak as if I were there."

The scribe looked up at him. He was a small desiccated man with a scrawny shoulder showing where the drape of his garment left it bare, but he wore a curled beard made of wool, like a priest.

"That's true, brother," he admitted. "Even an untutored donkey like you may speak at a distance, with my help. But it will cost you one-third of a shekel."

Shum-il winced. He had learned soon after his arrival that everything was expensive in the city of Ur. But then, Ur was far more grand and sophisticated a place than a backwater like Kish.

He temporized. "And my words themselves, my words will go to Kish?"

"Haven't I said so?" The scribe showed his impatience. "Once long ago, before the time of the Flood, scribes could only scratch little pictures in the clay. But then Enki, the god of learning, taught us to make signs in the clay by means of arrangements of wedges. Thus, the sign for a foot may become the word that means walk, and the sign for a mouth may mean to speak. It only needs another scribe to read the marks and make words of them."

"But how may I be sure . . . ?"

"Do you wish me to write your letter or not?" the scribe said, coldly.

Shum-il sighed and handed over the third part of a shekel. The scribe dipped into the pile of wet clay beside him and quickly fashioned a small tablet, patting it expertly into shape. He took up a reed stylus and begrudged a smile. "You may be sure," he said, "that I am a scribe whose hand moves in accordance with the mouth. Now, begin."

Shum-il cleared his throat and said, "These are the words of Shum-il, son of Lugal-sin the gardener, to his brother Buzu. My brother, make all haste and come to Ur, for the streets tinkle with the sound of gold, and the land is bountiful. By these words I tell you to mortgage my field to the *ishakku* and also to sell the cattle, but the oxen you are to bring with you. Make an offering to Ninkilim, the goddess of field mice, that she may not plague us in Ur. . . ."

The letter arrived in Kish on the fifth day after the next Moon, and Buzu paid the messenger a third of a shekel, as the inscription on the clay envelope—so the messenger claimed—required. He looked at the indecipherable marks for a while, scratched his head, then took the letter to the scribe, Ku-nanna, to be read.

Meleagros the Theban turned to

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his new amanuensis, yawned delicately behind a perfumed hand, and said, "Fetch your tablet." He had purchased the man for only two hundred drachmas, and had been even more pleased at the bargain when he discovered that the fellow was skilled in the Ionian form of writing. Meleagros himself could read and write, of course, but it was not seemly for a gentleman to soil his hands with labor best left to a slave.

"We'll continue with the dithyrambs to Dionysus today, I think," Meleagros drawled. "Where did we leave off?"

"At 'twice-born god, drawn from the thigh of Zeus,' master."

"Hmmm.... In your sacred revels, we too are reborn.... No, change 'revels' to *ekstasis*."

Obediently, the amanuensis smoothed over the wax with his thumb and substituted the new word.

Meleagros nodded with satisfaction. That was the advantage of the new system—you could correct words before transferring them to papyrus. It was an improvement over the clay tablets of the eastern peoples. The alphabet, though, was the real improvement. One sound to a letter, from a small number of which one could construct any word. The Assyrians still used their barbarous wedges, and made their words one by one.

At present, at least ten different Greek alphabets were competing among the warring city-states, but Meleagros was willing to bet that the Ionian writing, used by Athens and the more civilized cities, would ultimately prevail and become the writing of the future. There would be immortality for his poetry.

The amanuensis was waiting patiently, his stylus poised. Meleagros strove for a phrase worthy of posterity.

"Satyr we are, and Nymph as well," he dictated. "Wait, change that to...."

A shadow fell across the parchment, and Brother Ambrose looked up to find the abbot standing at his shoulder. "Come, Brother," the abbot said gently. "Your labors are needed in the guest house. Bring parchment, ink, and pen."

"First let me finish copying this page," Ambrose said. "I have but two more lines."

Despite his protest, he was not averse to leaving. It was cold in the scriptorium, and his fingers were numb after twelve straight hours of transcribing a Lives of the Saints.

"Leave it for now," the abbot said. "I know you've been promised a sin forgiven for every line copied, but sins can wait."

There was the glint of money in the abbot's eye. "Is it Sir Eustace?" Brother Ambrose asked.

"Yes. He wants a letter written."

"Another one? He wrote a letter only last year."

"He's getting old. He's left too much unsaid. This one is to his old foe in Burgundy."

Brother Ambrose gathered up his writing materials, choosing, after a moment's thought, a well-scraped square of parchment that had been

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used twice before. For a letter, it wouldn't matter.

Sir Eustace was pacing impatiently when they arrived. Somebody had had the wit to bring him wine, and he paused to toss off the remains of his goblet before turning to face them.

He was a large, inordinately broad-shouldered man, with an amazing number of scars from his many campaigns. The greasy locks were gray now, and the great red beak of a nose stood out a little more prominently from a wintry face.

Ambrose arranged inkpot, quills, and parchment on the table. "Are you ready to begin, my lord?" he inquired.

Sir Eustace scowled. "To my friend and worthy foe, Geoffroy de Toucy. Sire, it has come to me that it has been many years since we have had the pleasure of lifting sword or lance against each other, or indeed, together against our common foe, the infidel. The days grow short and dull. I propose that we meet one last time in the lists, with unblunted lance and naked blade, to see, at long last, if God ever intended for one of us to kill the other. . . ."

When he finished, he had Ambrose read the letter back to him, then laboriously traced out his signature. Sir Eustace, though he could not read or write, was able to sign his name.

The following spring, when the letter arrived in Burgundy, Geoffroy de Toucy's long equine face lit up in pleasure at the sight of the red wax seal. "It's from my old friend Sir Eustace," he said to his page. "Run, boy, and fetch that pestilent Brother Bernard who sits in my kitchen and devours my substance! He can earn his keep for a change and read the letter to me."

There were still piles of correspondence waiting to be dealt with, including the rather urgent memo from the foreign office which could not be put off any longer, so Lord Trumpton greeted the arrival of his secretary with a sense of relief.

"Shall we plunge right in, my lord?" his secretary asked.

Lord Trumpton made a face. "I suppose we must. No, damme, I'll indulge myself a bit first. Take a letter to His Grace, Lord Moyne. He's taking the baths at Carlsbad."

"Very good, my lord."

His secretary, an imperturbable young man named Phipps, got out his pen, one of the newfangled quills equipped with a gold nib. It made for a finer hand and fewer blots, though it lacked the character of the old-fashioned turkey feather. Lord Trumpton thoroughly approved of the innovation. With it, Phipps could dash off a thirty-page missive in the same hand from beginning to end, without having to pause to trim the point.

Phipps was a treasure. Though Lord Trumpton was marvelously articulate and witty, he had an execrable hand and, if the truth be known, really did not spell very well.

"Dear Bootsy," he began. "You are very clever to have immersed yourself in the waters of Carlsbad in this dull season, when London is tedious and there is little gossip worth repeating, though I don't know if I shall

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forgive you for abandoning me here without the prospect of civilized conversation. . . ."

Lord Trumpton paused to consider his further words. Even in this great age of letter-writing he had a reputation as a scintillating correspondent, and he was vain of it.

"Mr. Pitt grows wearisome, and his wife, the Bottomless, is able to illuminate a drawing room by leaving it. No, Mr. Pitt does not compare with his father, the First Earl, whose advice, had the otherwise estimable Lord North had the sense to follow it, might have enabled us to hang on to the troublesome American colonies. . . ."

Phipps scribbled on, discreetly changing a word here and sharpening up a phrase there. He had a reputation to uphold, too, and Lord Moyne's secretary, a fish-eyed individual named Wilkes, was quick to notice a slipshod job of polishing.

The typewriter had come from the Chicago Visible Typewriter Sales and Rental company, and its operator, Mrs. Fickett, had come from the Mrs. Atherton Agency. Thaddeus T. Bigney, senior partner of Bigney & Stoddard, Inc., stood in the doorway of his oak-paneled office and admired them both.

There was much to admire about Mrs. Fickett. She made a fine figure sitting straight and stiff at her machine in her crisp ruffled blouse and ankle-length skirt. Mr. Bigney did not fail to notice that the ankle revealed by the new shorter style was trim.

The typewriter, too, was admirable. It was the latest model made by E. Remington & Sons, with a lever that enabled the operator to type small letters as well as capitals, and the Visible feature that showed each line as it was actually being written.

"Uncle Thaddeus, you old dog!" said a voice behind him.

He turned to see his nephew, Arthur. Arthur looked untidy and unbusinesslike, as usual, with a rumpled suit, ink-stained fingers, and a popped collar button.

"Don't jump to conclusions, Arthur," Mr. Bigney said. "She's a respectable widowed lady. These typewriter machines are bringing more and more women into the office. The day will come when every business will have one."

"What? A woman or a typewriter?"

"Don't be facetious, Arthur. I know it's fashionable in your bohemian circles."

"Where's your clerk, Braithwaite?"

"I let him go. The typewriter can handle all my correspondence. And in half the time."

"It can't give you a straight right margin, though. Braithwaite was good at that. Finest penmanship I've ever seen."

"That's true. But you've got to move with the times, Arthur."

"You should see some of the manuscripts that come in at the journal. All blots and scrawls. Not that my own handwriting's much better—though I never noticed that good penmanship improved anyone's prose. Maybe I'll get myself one of those typewriters, just to give the compositors a break." He looked over at Mrs. Fickett. "You

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know, Uncle," he said slyly, "a man could write his own letters on that machine, with no one the wiser."

"No thank you, Arthur. It's not seemly for a man to know how to type. I'll leave that to women and you artistic types. I'll continue to dictate."

Arthur laughed. "Now who's not moving with the times?" he said.

"Hacks and journalists. That's who you're talking about. The sort of people who don't use a secretary."

"Exactly," Arthur said seriously. "It'll be a godsend."

Johnny Travers stared at the sheet of paper in the typewriter and waited for inspiration. What would it be? A western? A detective story? An air wars short? Or maybe a pseudoscience fiction story this time. He lit a cigarette and thought it over. F. Orlin Tremaine over at *Astounding Stories* paid a princely two cents a word, but he was always overinventoried.

He decided on a western. *Wild West Weekly* was usually good for a sale, and they paid every Friday. If he didn't sell it there, he could probably unload it at *Dime Western.*

He poured himself a cup of black coffee from the coffeepot at his elbow, and lit another cigarette. All he needed now was a plot. Or at least a good first sentence.

The phone rang. It was Steve Gifford of *Stirring Crime Stories.* "Johnny," he said, "I've got a hole in the next issue. Can you give me seventy-five hundred words by tomorrow morning?"

"Sure," Johnny said. "Anything particular in mind?"

"I've got the illustration here. Roger Dixon was supposed to write something to go with it, but he went off on a toot. Want to come over and have a look at it?"

It was a half-hour subway ride to the offices of Stirring Publications. Johnny said, "Just describe it to me."

"Well, it's a speakeasy scene. Three hoods just broke into the place. Two of them have tommy guns, but the guy in front has a missing hand, and instead of a hook fitted to the stump, he has a morningstar."

"A what?"

"A morningstar. It's a kind of mace—iron ball with spikes—that knights used to fight with, and he's swinging it on a chain. There's a screaming broad and a bartender diving for a shotgun."

"OK. Seventy-five hundred words, you said?"

"Let me check the pasteup. It comes to exactly a hundred sixty-five column inches."

"OK. You'll have it in the morning."

He set his typewriter margins for seventy-two characters. That was equal to two of *Stirring Crime*'s columns, and it would average out. Seven lines to the inch. He'd pace himself at the end and finish right on the button. It was marvelous what you could make a typewriter do.

If only, he thought, they made a machine that caught spelling errors. But the typesetter usually fixed small mistakes anyway, if he was sober.

He leaned back in the kitchen chair. Let's see, the hood lost his hand in a gang war. He got the idea for the morningstar by watching a wrecking

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ball outside his hospital window. Instead of a violin case, he uses a bowling ball bag to conceal his weapon. He's after revenge on the rival gang that did it to him.

He needed a title. *The Revenge of Johnny Cremona.* He hunched over the keys and started typing, as fast as two fingers could go.

"I don't like it," said the tall man with the impressive mane of white hair. "It all looks so . . . intimidating. That illuminated screen staring at you. That blinking dot, what do you call it, a cursor. All that computer gobbledygook to remember."

"You'll get used to it." The second man was short, bald, muscular. "I guarantee it. In fact, you'll get to depend on it."

"But—"

"There's no other way, Senator," the other said firmly. "You've diddled away a whole year. Your deadline's right on top of you. If you don't produce those tell-all memoirs while you're still hot, you'll have to give back that two million buck advance." He smiled engagingly. "And where would that leave me?"

The senator returned a crocodilian smile. "You could give back your commission."

"Not a chance."

"I hate the name. Word processor. It's part of the new barbarism. As if words were so many turnips, to be sliced, diced, and shredded."

"You're behind the times, baby. Nobody uses a typewriter any more. The last of my clients made the switch years ago—an old geezer who used to write for the pulps. Even he had to give in when his antique Remington broke down."

"I never even learned to type, you know. In forty years of public life I got along with a legal pad and a pencil."

"That's the beauty of it. You don't *have* to be much of a typist. The machine will jump through hoops for you. Just hunt and peck. If you make a mistake, you can fix it."

"You make it sound easy, Leo. But I still have to face that blank screen every morning."

"I don't know what more I can do, Senator. Unless you want me to get you a ghostwriter."

The senator bristled. "I'm not one of your bubbleheaded Hollywood clients, Leo. It's my book. I'll write it myself."

"Then you've got to bite the bullet."

After the agent left, the senator sat down in front of the new word processor. There had been a man to explain it to him, walk him through the tutorial disk, and he remembered to punch in the menu. The screen flashed its readiness. He tentatively pecked out a few words. He gained confidence little by little. By the end of the first hour, he was tapping away at almost a line a minute.

Sebastian Q. Beebe, Megagroup 4B, stared out the mile-high window of his domicilium at a beautiful day. The Sun was coming up through a golden haze of orbiting solar UV screens, glinting off the plastic-carpeted cropland to the east and making the dis-

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tant ocean sparkle. The nearest other metrostack was more than three miles away, its shadow hardly touching the base of Sebastian's hab. It was an age of elbow room.

There wasn't anything to do for the moment. They were clearing an overnight virus out of Omninet, and he wouldn't have any work coming through for a couple of hours. It was a perfect time to catch up on his correspondence.

He flopped down in a comfortable chair next to his old-fashioned Wordmaster, and said, "On." The screen lit up, and the machine replied, "Ready."

It was a clunky antique that still had a keyboard. You didn't see many of those around any more. It really couldn't do anything that his personal AllComm couldn't do better, but he'd had it for years and felt a certain affection for it.

"Take a letter," he said, "to Professor Florian T. Magnus, at Jov-Hab. Do you have his electronic address?"

"Yes," the machine said, and the screen displayed a string of letters and numbers which Sebastian ignored. It went on to read them punctiliously aloud, and Sebastian paid no attention to that either.

"Dear Professor Magnus. . . ." he began, then paused to gather his thoughts. He was still a little in awe of Professor Magnus, and flattered by his continued friendship after all these years since graduate school, and he would not have dared to fob him off with an indifferent effort.

". . . I must apologize," he went on, "for taking so long to answer your last epistle. It was a treat, as always. I'm sorely tempted to migrate to Jov-Hab myself. Life on Earth seems so—" Sebastian smiled to himself, "—mundane compared to the pleasures of life in Jupiter orbit you described so eloquently. I was particularly struck by your description of the double eclipse of Jupiter and Callisto by Himalia during your last circuit. . . ."

The words flowed across the screen in the personalized typescript the machine had devised for Sebastian. He did not bother to watch them. You could trust the Wordmaster to get it right.

Anyway, all those little squiggles only gave you a headache.

It was over an hour before the letter arrived at Jov-Hab. Jupiter was currently on the opposite side of the Sun, and all signals had to be relayed through Vesta. Professor Magnus's AllComm chimed and, recognizing the rubric for printed documents, spewed the three incoming pages into its tray.

Professor Magnus found the letter waiting when he returned to his quarters after lunch. He put it under the scanner and settled back in his chair to listen to it.

"Dear Professor Magnus," the machine said. "I must apologize for taking so long to answer your last epistle. It was a treat, as always. . . ."

Professor Magnus smiled to himself. Sebastian had turned out well. It was civilized of him to take the trouble to transmit the written word when most people these days contented themselves with sending images of themselves jabbering at a lens. It was good to know that some of his

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students still believed in upholding the standards he had tried to instill in them.

He used a thick forefinger to follow the words on paper as the AllComm's synthetic voice droned on. Some might call him an old fossil, but he was proud of his little outmoded ability.

Here and there he could make out a letter by its shape, and that helped him to keep his place. When he got lost, he could always catch up by matching sequences of long words and short words. He recognized his own name on sight, of course, and quite a few of the more common words with distinctive shapes.

He chuckled approvingly when the scanner got to Sebastian's little play on "mundane." Words were marvelous things, he thought. It was satisfying to be able to trade them back and forth with someone who appreciated them.

He folded his hands and spoke to his waiting machine. "Take a letter," he said—. ■

To die for an idea is to set a rather high price on conjecture.

Anatole France

To die for an idea; it is unquestionably noble. But how much nobler it would be if men died for ideas that were true!

H. L. Mencken

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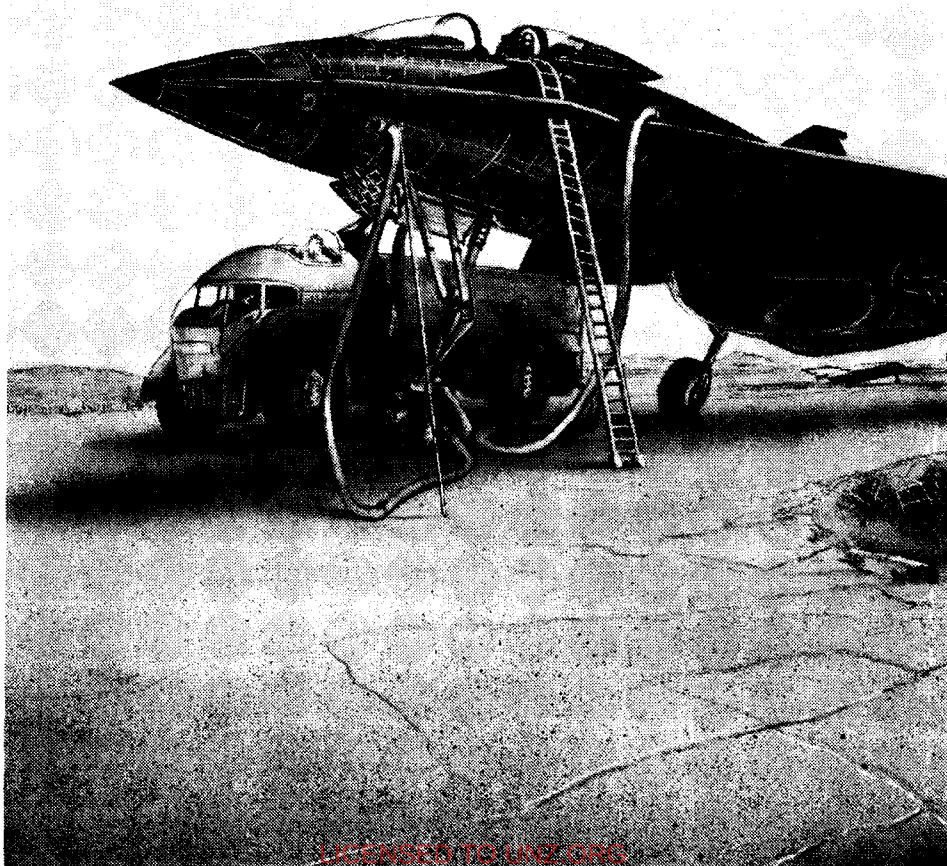
Catherine Asaro

LIGHT AND SHADOW

Test pilots always work with the unknown, but some trips have more of the unexpected than others!

Illustration by Randy Asplund-Faith



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Kelric spoke into the empty air of the cockpit. "Glint Control, I'm ready to give it another go."

"Standby, Glint One Eight." Lieutenant Tyrson's voice came over the audiocom, sounding so clear he could have been right next to Kelric's reclined seat instead of on the ground far below. "Glint One Eight, tracking and instrumentation are go. You're cleared for test procedure four. Calculations indicate your wing stress will be within safe limits."

Safe? The thought rose in Kelric's mind, unexpected, coming out of a hidden corner. So what? You have nothing worth keeping safe.

Kelric banished the thought back to its dark corner. Then he whipped the plane through a dizzying set of loops and rolls, uncaring of the *g* forces that pressed him into his seat. He lay more than sat in the tight cockpit, with the computer console and display panels in front of him. Data streamed across the visor of his face plate, changing so fast to keep up with his maneuvers that it blurred. Holomaps of the planet Diesha turned on his screens, the deserts shaded like orange and red paint mixing on a palette. Isolated mountains broke the land's flatness in convoluted spears, and no clouds showed in a sky so blue it almost vibrated.

Kelric pulled out of his last loop, once again in control of himself, once again relishing the flight. He grinned. "How does that read, Lieutenant?"

Tyrson chuckled. "Like a dream."

And what a dream, Kelric thought. He was the first pilot to test the Glint-18, a rocket fighter powered by nuclear fusion that made other planes he had flown seem like slugs.

Captain, the Glint's computer thought. *How can a dream read?*

It's just a figure of speech, Kelric thought, directing the reply with more intensity than he used when his thoughts were for himself only. He touched the valve in his survival suit where the prong on his pilot's seat plugged into his spine. It connected the cyberware built into the plane with the network of cyber fibers implanted in his body. His motion was reflexive, a reminder that he was linked to a computer and not a person. The Glint's efforts to learn idioms made it seem self-conscious to him, like someone new to a language who dreaded using the wrong phrases for fear of looking foolish.

"Captain Valdoria," Tyrson said. "I can't access mod four of your computer."

"Checking," Kelric said. *Glint,* he thought, *run a diagnostic on your fourth mod.* The mod controlled the extra shielding against heat, ultraviolet radiation and cosmic rays that the craft needed for space travel. Although this wasn't the first plane Kelric had flown with space flight capability, it made the others seem like wallowing jumbos. But today his tests concerned only its performance in a planetary atmosphere.

Lights suddenly blazed across his controls, glowing like holiday decorations. *Altimeter error,* the Glint thought. *Environment control error.*

Tyrson's voice snapped out of the audiocom. "Glint One Eight, your chase planes have lost all contact

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with your—"

As Tyrson's voice cut off, the Glint added, *Audiocom failure.*

Slow down, Kelric thought. The rockets fired, but the plane hadn't turned, so it sped up instead.

Cockpit pressure dropping, the Glint thought. *I've sealed your survival suit.*

What was going on? *Glint, slow us down.*

Neither the thrusters nor the attitude jets are responding, the Glint answered.

Reboot their control mod.

Reboot successful. Then: *Captain, we're approaching escape velocity.*

Kelric stared at the console. To escape the planet's gravitational pull he had to go over eleven kilometers a second, far faster than he had prepared for on this flight. This was crazy. He couldn't go into space.

Then a thought stirred in the hidden corner of his mind: Why not? You have nothing to lose. Nothing worth keeping.

The Glint's thought cut through his own: *Do you want to try slowing down again?*

Kelric sat motionless, watching the planet withdraw from him. All of his holomaps showed images of Diesha receding now.

If we don't slow down within eight seconds, the Glint thought, *we won't have enough fuel to return to base. In fourteen seconds we won't be able to reach any emergency landing site.*

Kelric's private thoughts whispered to him like a faint strain of discordant music playing under the computer's voice: you can drift in space forever. With the stars as your lovers, you'll never be alone.

Escape velocity achieved, the Glint thought. *We are leaving the planet.*

With a mental heave, Kelric snapped himself back to reality. *Return to base.*

At first nothing happened. Then he felt the thrusters rumble in their bay. Finally the rockets fired, flattening him into his seat.

Re-entry initiated, the Glint thought.

Kelric exhaled. *Do we have enough fuel to get back?*

Yes.

So I'm going to live after all, Kelric thought. He wasn't sure whether to be grateful or to curse.

"We weren't able to analyze much of your cyber log," General Schuldman said. He had seated himself behind the darkwood desk in his office. The room was huge, as spare and strong as the grey-haired man who used it. "Most of the log was garbled. Do you have any comments to add to our quick-look report?"

Kelric was sitting in front of the desk, uncomfortable in a leather-bound chair. Had Schuldman gleaned any hint of his lapse in judgment during the flight? But if that had happened Kelric doubted he would be here now. Given Schuldman's reputation, he suspected the general would have already sent him to pack his bags for a new job.

"There's a flaw in the Glint's computer, sir," Kelric said. "I think it's in the cyber-hardware interface."

Schuldman nodded. "Apparently it

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tried to break the cyber lock that keeps it out of your private thoughts. When your mind blocked it, the entire system froze up."

His private thoughts. Kelric somehow managed to keep his face bland. Now he understood. The computer must have caught a hint of his erratic thoughts and tried to process them. "Can it be fixed?"

"It already has been. It won't try to break your cyber lock again." Schuldman considered him. "Engineering also ran calculations using the higher velocity data you obtained. Their results suggest the Glint may indeed be able to withstand the huge accelerations Dr. Zaubern claimed in her first reports."

So Jessa Zaubern had been right after all. It didn't surprise Kelric. "Sir, the Glint's engine can't achieve the accelerations she predicted."

Schuldman regarded him steadily. "That's why we put an inversion engine in it."

They put a starship engine in a *plane?* Were they nuts? Schuldman was watching him with a scrutiny that made Kelric wonder again if the general knew about his faulty judgment. But given the Glint's computer failure, all Schuldman could know was that his pilot had let the plane leave the planet when he could have prevented it.

Kelric spoke carefully. "Even with the high speed data from my last flight, the best the calculations can do is give a rough idea of what will happen at the higher velocities."

Schuldman continued to study him. "That's why I'm looking for a volunteer to test the modified aircraft."

Kelric knew the general's ability to get fast results made him one of Space Command's most valued officers in the Space Test Wing. And he had heard that Schuldman considered him the best test pilot at the Arosa Space Force Base. He had also heard the rumors that Schuldman earned his reputation by pushing his planes, and their pilots, to the limit.

But what a ride it would be, taking the Glint up with an inversion engine. Kelric almost grinned. The speed, the challenge of it, pushing the edge —the idea exhilarated him. Then he thought of the risks and sobered up. Neither the Glint nor any other plane he knew was ready to fly with a starship drive.

Unbidden, a thought crept out of the shadowed corner in his mind: Go ahead. Do it. You have nothing to lose.

Nothing worth keeping.

Kelric spoke. "I'd like to volunteer, sir."

Schuldman nodded. "Very well, Captain. The flight will be in three days. Report then to missions operations at zero five hundred hours."

The only light in the sunken living room came from a clock on the wall, its violet glow coaxing gleams from the glassy furniture and the glassy paneling. Moonlight poured through the window that filled the north wall. Outside, far below, the city of Arosa lay under the desert sky, its scattered lights glittering like moonlight trapped in a diamond. It was the only

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town within a one day hovercar drive of Arosa Space Force Base, an installation isolated so far out in the desert that nothing but an occasional corkscrew cricket lived near enough to see the aircraft tests.

Kelric sat in the dark glossy penthouse, sprawled on the dark glossy couch, holding a glass of desert honey in his hand. He had no idea where the whisky got the name honey. It tasted like cleaning fluid. He grimaced and poured his drink back in the bottle, then clunked the tumbler down on the glass table in front of him.

"So," he muttered. "You like sitting here in the dark or what?"

"That's a good question," a woman said.

Kelric jumped to his feet so fast he knocked over his glass. The lights in the room came on, blinding him. As his vision cleared he saw a statuesque woman by the door, a golden figure with an angel's face and masses of radiant curls that floated around her face and spilled down her back.

"For heaven's sake, Mother," Kelric growled. "What are you doing here?"

She smiled slightly. "I'm glad to see you too."

"You surprised me." She rarely just showed up at his door. It took over an hour to reach Arosa from the city where she lived. "How did you get in?"

"You left the door open." She walked over to him, her lustrous hair floating out behind her. "I thought something was wrong. Then I heard you talking to yourself."

"I wasn't expecting visitors."

Her smile smoothed away the worried furrow that had creased her forehead. "I decided to come after I saw you on the news tonight."

Kelric reddened. He was trying to forget the broadcast. News of his last flight had leaked and a local reporter called the base to ask if she could interview him. Schuldman gave the go-ahead, not knowing Kelric avoided public speaking like he avoided jumping into hot tar pits. The project information officer told him to satisfy the press with a good story so they wouldn't investigate further and possibly find out about his upcoming flight. Kelric had tried to prepare for the interview, but when he walked into the broadcast studio with its bright lights and buzzing crews, it rattled him so much that he hadn't been able to do much more than mumble yes and no to the reporter's questions.

"That was quite a story." His mother beamed. "How did they put it? 'The brave and handsome hero of Space Command.' "

"I looked like an idiot."

"Actually, I thought you fit the role of hero well."

He couldn't help but smile. "You would think I was heroic if I fell on my face in the mud."

She chuckled. "You looked every bit the valiant flyer they made you out to be." Her smile faded. "But I know you, Kelric. Something was wrong."

"I hate speaking in public. You know that too."

"It was more than that."

"I don't know what you're looking for." He picked up the whiskey glass.

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"I don't mean to be rude, but I'm tired. I don't much feel like company tonight."

She spoke quietly. "Sitting here alone in the dark won't bring Cory back to life. And committing suicide in your fancy plane won't bring you any closer to her."

He went rigid. "Good night, Mother."

"Kelric, it's been two months since Cory's funeral." Her voice softened. "In that entire time, I've never seen you shed a single tear, or heard you say one word about it. You sit up here, surrounded by her things, brooding. It's not healthy."

He spoke tightly. "This is where I live."

"You can change where you live. Find a place that isn't full of memories."

Memories? He didn't even have those any more. His wife's death had left a void in him with nothing but grief to fill it. Why had he married another officer? Losing a friend in battle was hard enough. When the news had come, two months and an eternity ago, that the battlecruiser Cory commanded had been destroyed —and she with it—a part of him had died as well.

Kelric pushed down the memory. He didn't want pity. What could he do to make his well-meaning mother go away before her solicitude started him unraveling?

After a moment he said, "I'll look at apartments next week."

Her luminous face lit with a smile. "There's a nice place on Arroyo Cliffs. You could see it Tillsday evening."

"All right." That would be well after his test flight of Schuldman's mutant plane with its starship engine.

Dawn's ruddy light stretched cacti shadows across the red sands. It turned the airfield crimson and reflected off the hull of the Glint like sparks of fire. Out in the desert that surrounded the base nothing but rock spires showed as far as the horizon. Only the rare buzz of a corkscrew cricket interrupted the dawn's silent splendor.

Kelric walked around the Glint. The only visible changes in it were the photon thrusters mounted behind the rocket exhaust. But inside the plane a marvel hung ready to shoot him into the heavens. Or into hell, depending on how he looked at it.

Inversion. The word had fascinated him since childhood. At the Academy he had earned his degree in inversion theory, the physics of faster-than-light motion. Yet to reach supraluminal speeds should have meant going through light speed, which meant slower travelers would see his mass become infinite and his ship rotated so that it pointed perpendicular to its true direction. Time on his ship would stop relative to the rest of the Universe. It was all impossible. So how could he ever go faster-than-light?

The answer turned to be simple.

It depended on imaginary numbers, the square roots of negative numbers. Special relativity said his mass and energy became imaginary at supraluminal speeds. If he also added

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[illegible] her under her [illegible] with other. Both of [illegible] awkward- [illegible] she's also the only [illegible] at Dic- [illegible] game invented [illegible] circle of card [illegible] she was a better engi- [illegible] she had tri- [illegible] it was in good

[illegible] the Orbit. Then she [illegible] the fusion rock- [illegible] planet. Then use [illegible] You got posi-

[illegible]. Positrons for [illegible] a hard time be- [illegible]."

[illegible]" she motioned to- [illegible]. "We used EM fields [illegible] canister. When [illegible] object in the [illegible] positrons into the [illegible] as a starship."

[illegible] Kelric had [illegible] the plane carrying [illegible] engine, complete with a se- [illegible]. The wheel- [illegible] electrons out [illegible] that in space, letting [illegible] in highest energies en- [illegible] gamma and baryabos. Once in- [illegible] electrons annihilated with [illegible] there, creating [illegible] photons that re- [illegible] energies.

[illegible] as it does what it's [illegible]," he said.

[illegible] a film. "You think it [illegible]?"

[illegible] Of course not."

[illegible] something you?"

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For a moment he just looked at her. Finally he said, "I'll only be carrying a hundred kilograms of positrons."

"Only? That's more than you need. It's not like you're going anywhere." Her face relaxed into a smile. "Kelric, one gram of positrons makes a million billion billion annihilations. That's a lot of push."

Although his mind balked at accepting her reassurances, Kelric knew she was right. He tilted his head towards the Glint. "So is it true? Can she really go 1 percent of light speed?"

"Should." Jessa paused. "We don't have enough data yet to do accurate calculations for velocities higher than that."

That sounded intriguing. "You mean you don't know its top speed?"

Jessa scowled. "Don't even think of it."

"Think of what?"

"You be careful with my plane."

He grinned. "I'm going to wreak havoc on it."

"Very funny. You be careful with Kelric, too."

"I'll wreak havoc on him, too."

"I'm not joking." Jessa shook her head. "People look at you, they see big and quiet. They don't think you feel. They don't think you think."

What had brought that on? His smile vanished. "It doesn't bother me."

Her voice gentled. "I know it does, Kelric. But you're smarter than all of them put together. And you feel. Too much. You keep thinking and feeling and locking it up. It will eat holes in your heart."

He swallowed. "I'm fine."

"Only one dumb thing I've ever seen you do," Jessa said. "That was agree to take up this plane. Schuldman had no right to push you into it."

"He didn't. I volunteered."

"Like hell." She poked her finger at his chest. "I want my plane back in one piece."

"It's not your plane, Zaub."

"Just remember what I said."

"All right."

"Well." She paused awkwardly. "Good luck."

The tense set of his shoulders relaxed. "Thanks."

After Jessa left, Kelric climbed into the cockpit and ran more tests. He put the computer through every one of its routines and it answered without a glitch.

Although the Glint could take off vertically, today Kelric tested it on the runway. After Tyrson gave him clearance, he sped down the asphalt and soared into the air, once again exulting in the feel of acceleration pushing him against his seat.

As he shot through the sky, climbing higher and higher, Diesha spread out on his holomaps in a desolate landscape of sunrise colors. He accelerated steadily and the Glint answered like an extension of his own body. Its wings folded back against its fuselage, cutting drag and preparing for the supersonic shock wave. Mach 1, Mach 2, Mach 4. Finally he hit the speed where the computer had developed jitters during his last flight.

"Glint One Eight to Glint Control," Kelric said. "Systems look good here."

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"I read the same," Tyrson said.

"Good." Kelric grinned. "I'm going to give it a kick."

Captain, the Glint thought. *I don't think kicking me will serve any purpose.*

Kelric smiled. *Just another idiom.* He fired the rockets again, breathing in grunts to keep from blacking out from the *g*-forces. Mach 8, 16, 32. He hit escape velocity and kept going. On his screens, Diesha gradually changed from a curved landscape to a turquoise globe studded with ruby deserts.

"She's beautiful," he murmured.

Tyrson chuckled. "Is that someone you see up there, or are you thinking about your last date?"

"Lady Diesha," Kelric said. Beautiful sorceress, he thought. Hold me in your arms until the pain stops.

We've cleared the planet, the Glint thought. *Do you want to start the inversion engine?*

Let's give it a go. Kelric fired the photon thrusters—and went into stasis.

Without the stasis coil, he would have been smeared all over his seat. The burst of radiation produced by the engine could accelerate the craft up to thousands of times the force of gravity.

The waveform modulators in the coil worked on an atomic level, keeping the quantum wavefunction for the ship from changing state. What it meant was that during stasis nothing could alter the configuration of particles in the plane or anything it carried; together, he and his craft became a rigid solid that no force could deform. Only the atomic clock that limited their stasis time was unaffected. Kelric felt nothing; the only way he knew he hadn't been conscious the entire time was by the sudden jump in speed on his display.

Tyrson's voice burst out of the audiocom. "Captain, she's working like a dream!"

Thanks, Zaub, Kelric thought. He fired the thrusters again and his speed suddenly read three thousand kilometers per second.

"Glint Control," Kelric said. "I'm at 1 percent of light speed."

"We read you smooth as silk," Tyrson said. "It's beautiful."

It's empty, Kelric thought. Empty. "I'm going to crank it up again."

Another voice came up over the audiocom. "Captain, this is General Schuldman. Your systems are operating well, better in fact than predicted. The decision to exceed this speed is yours, but if you do so you will be going against the advice of the team that installed your engine. Do you understand?"

Kelric knew Schuldman wanted him to push the Glint to its limit. He also knew the general meant to make sure he knew the risks. "Understood, sir."

Then he fired the photon thrusters.

Kelric was suddenly aware of a vibration, a gentle shaking but still one that didn't feel right.

"Captain!" Static crackled in Tyrson's voice. "I'm reading you at 10 percent of light speed."

"Captain Valdoria." Schuldman's voice came through the static. "That's fast enou—"

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Kelric fired the thrusters, cutting off Schuldman's voice. The display jumped to one hundred thousand kilometers per second. He hit the thrusters again and the number doubled. He was going at two-thirds the speed of light.

A voice on his audiocom drawled. "Are you recei . . . return to base . . ." Then the words faded again.

For a moment Kelric had no idea who had spoken. Then he realized it was Schuldman. *Glint,* he thought. *What's wrong with the audiocom?*

It can't cope with time dilation.

Kelric blinked. Starship audiocoms could easily compensate for the effects relativistic speeds had on radio waves. But the Glint didn't carry a starship audiocom. He wasn't supposed to be going this fast.

How long does Control think we've been gone? Kelric asked.

Thirty-three minutes, the Glint thought. *My internal clock says thirty minutes have passed for us.*

Kelric gave a short laugh. *How about that? We jumped three minutes into the future.* When he went this fast, Control thought his clock ran slow. But he thought the clocks on Diesha ran slow, because to the Glint it looked like Diesha shot off in the other direction while the plane stayed still. Only when he turned the Glint around did it break the symmetry of their relative motion. What it meant was that when he came home, the record of his clocks made at the base would be the right one. He would be several minutes younger than everyone there.

Captain. The Glint's thought cut through his mind. *The strain on this craft exceeds all advised safety limits.*

No one ever claimed this job was safe, Kelric answered. *How fast can you go, sweet Glint?* Fast enough to blow the grief out of his heart? Could any craft take him that fast, that high, that far?

I also register a strain in your mind greater than advisable safety limits, the Glint thought.

Who programmed you to tell me that? Jessa Zaubern?

Captain, I advise you that we should return to base.

Kelric watched his visored reflection in the console. *Can we invert?*

I don't know, the Glint thought. *But if we do, we won't have enough fuel to get home.*

Raise the beambox threshold. By scooping up only the higher energy electrons, he could extend the range of his positron fuel.

If I raise it, the Glint thought, *you will run out of air before we find enough electrons.*

Then invert the fuel first.

I see no reason to—

The cosmic ray flux is higher in supraluminal space, Kelric thought. *We'll find electrons a lot faster there.*

Photons produced by annihilations in imaginary space will do us no good here, the Glint answered.

Sure they will, Kelric thought. *If I release a flock of birds by an open window, some of them are bound to fly through it. As long as the engine operates here, some photons will invert back here.*

That violates energy conservation.

Who had programmed the com-

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puter to argue with him? *No, it doesn't. What we gain, imaginary space loses.*

Photons are not birds. The Glint was beginning to sound like Jessa Zaubern. *Inversion engines are not windows.*

Just do it.

Captain, you may not survive this procedure.

Are you refusing to accept my commands?

Yes.

Kelric frowned. *You can't do that.*

What you suggest could be fatal. It amounts to throwing away your fuel.

The hell it does.

The only way for imaginary photons to become real, the Glint thought, *is for their existence quantum number to change from zero to one. That doesn't happen spontaneously.*

So what? Kelric thought. *Nothing spontaneously inverts. If starship engines can force starships to do it, they ought to work on photons.*

There was a long pause. Finally the Glint responded. *A finite probability exists that you are correct.* After an even longer pause it added, *I am unable to refuse your command.*

Good. Kelric glanced over his displays. *Reset the engine to invert the fuel in it in .1 percent increments.*

Engine reset.

Kelric fired the photon thrusters—and his speed jumped to 98 percent of light speed. The stars leapt on his holomap, converged towards a point in front of the plane. Data flashed on his displays like exhibitionists trying to shock him back to rationality: if Glint Control could still track him, they would read his length as shrunk by 80 percent and his mass increased by 500 percent.

Why didn't we invert? Kelric asked.

We need to get closer to light speed, the Glint thought.

Kelric frowned. *Starships manage from a lot slower than this.*

Starships have entire systems dedicated to optimizing their inversion capability, the Glint thought. *I don't.*

Kelric knew he should return to the base before time dilation jumped him any farther into the future. He had already gained more than half an hour. But he couldn't make himself turn around. Up here he could speed away from the grief and the loneliness, from the hurting emptiness inside of him.

This time when he fired the photon thrusters, the reading on his display leapt to 99.999999 percent of light speed. His mass increased by a factor of seven thousand. The starlight turned into x-rays. In one minute, five days passed on Diesha.

We still can't invert, the Glint thought.

Kelric gritted his teeth and fired the thrusters again. Centuries passed on Diesha. Now they were all dead. All of them. Everyone he had ever loved.

Cory, he thought. I can't do it. I can't live in a Universe where the people I love are gone.

We still can't invert, the Glint thought.

Kelric fired the thrusters—

—And the Universe turned inside out, yanking him with it, his body and

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mind twisting inside out like a tortured Möbius strip—

The agonizing twisting stopped as suddenly as it had begun. Then the stars reappeared, their colors returned to normal but their positions inverted through a point that appeared to lie infinitely far in front of the plane. Kelric recognized none of the eerily distorted constellations.

We inverted, the Glint thought. *But it definitely wasn't as smooth as silk.*

Kelric took a shaky breath. *You're learning your idioms.* That was no inversion like he had ever experienced. He doubted he could survive it a second time.

I need you to specify a path in spacetime, the Glint thought.

He struggled to clear his mind. Time and space switched character here, like twins changing identities. Now he couldn't back up in space—but he *could* back up in time. An observer would see an anti-matter Glint going forward in time but flying backwards from its destination to its origin. If he worked it right, he could compensate for his time dilated leap into the future by leaping into the past here.

If only he could go back to before Cory died....

But no matter how much he wanted it, the final result of his trip wouldn't violate reality. The best he could do with a starship was come home with the same amount of time passing there as for him. With the Glint, he would be lucky to come out anywhere near when he left Diesha.

His displays weren't telling him anything either. The inversion had scrambled them. *Glint, how fast are you going?*

One trillion times the speed of light.

WHAT?

One trillion ti—

Slow down!

Kelric blinked at the gibberish on his displays. *Did anything happen?*

We slowed to 132 percent light speed.

How did we get going so fast before?

When we passed light speed our mass decreased, the Glint thought. *So we sped up, which made our mass decrease, which sped us up, which—*

OK. I get the idea. A thought rose out of a shadowed recess in Kelric's mind: Can you imagine a more spectacular way to die? Hurtle along at infinite speed with no mass and infinite length, your body turning to dust while time stops for the rest of the Universe?

And then what? he asked himself. You think Cory will be waiting? You think she'll open her arms wide, welcoming you to her bosom for killing yourself? He could see her glaring at him, her dark hair whipping in an imaginary wind.

"Cory, I miss you," Kelric murmured.

I don't understand 'Cory,' the Glint thought.

Kelric almost smiled. *I never did either.*

Cory's image spoke gently in his mind: Good-bye, Kelric.

Good-bye, Cory, he thought. Then he took a breath. *Glint, figure a course to get us home as near to*

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when we left as possible. And finally he formed the thought that was nudging past his grief, rising like a young bird lifting into the air for its first flight. *If there's a way to get back alive I want to do it.*

I'll do my best, Captain.

Kelric fired the thrusters. The stars shifted position, but nothing else changed. He fired the thrusters again, trying not to think about how little fuel he had left. The stars collapsed into a point, their sluggish photons lumbering towards him as he leapt farther and farther into the past. He fired the thrusters—

And ripped in two.

Kelric snapped like a rubber band pulled too far too fast, its torn edges writhing in space, screaming, screaming, screaming. . . .

Suddenly he was whole again. He felt disoriented, as if his body had reset.

"We inverted," the Glint said.

Kelric swallowed. *Why did it feel so strange?* After a moment he realized the Glint had used its audio speakers. He spoke out loud. "What happened?"

"The top of the plane, including the top of your body, inverted two picoseconds before the rest of the craft."

Kelric stared at the console. "Am I—normal now?"

"Essentially."

"What do you mean, 'essentially'?"

"Only 99.99 percent of your mass reinverted."

Good Lord, Kelric thought. "What didn't come back?"

"The missing molecules are distributed throughout the lower half of your body." Then the Glint added, "We gave it a go and most of us went."

Kelric managed a wan laugh, trying to ignore his bizarre mental image of 0.01 percent of his body doomed to hurtle into the past. "What happened to our cyber link?"

"The reinversion scrambled it."

"Can we still get home?"

"Yes. But we don't have enough fuel to slow down."

"Raise the beambox threshold more," Kelric said. "Then do the bit with inverting the fuel again."

"We still won't be able to collect enough fuel before you run out of air."

That was it? He had almost made it back only to find he didn't have enough fuel to stop? No. It couldn't be. He couldn't accept that. "There has to be a way to get home."

"Getting home is possible," the Glint said. "But when we arrive you will be dead."

He grimaced. "You're encouraging."

"What do you want me to do?"

Kelric touched the spare tank on his survival suit. "Can you tap my emergency air reserve?"

"I already have."

For a moment Kelric just sat, absorbing his situation. Then he snapped his fingers. "I don't breathe in stasis."

"This is true."

He grinned. "So crank up the beambox threshold and put me in stasis until we reach Diesha."

"It is unadvisable to your survival to remain in stasis that long."

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"Dying isn't too advisable to my survival either," Kelric said. "What's the problem with stasis?"

"It prevents the configuration of molecules in your body from changing as your environment changes. If you stay in stasis too long, then when you come out your molecular wavefunction may not be able to readjust without catastrophic fluctuations."

Catastrophic who? "What does that mean?"

"Every atom in your body will be hit with a force," the Glint said. "Most of the forces will be different directions. The more your environment changes, the bigger the discrepancies. It could tear you apart, atom by atom."

"Glint, you're my environment. And you go into stasis, too. So you can't change."

The computer paused. "I calculate a finite probability that this could protect you. However, my environment will change."

"Not much. We're in space."

"Space is far from a true vacuum," the Glint said. "And it won't take much to make the plane collapse. Its structure is already strained past all safety limits."

Kelric thought for a moment. "Can you set the timer to bring us out at periodic intervals, before our stasis time becomes too long? We would only need an instant to readjust. I probably wouldn't even be conscious of it."

The Glint was silent again, and Kelric could almost feel it calculating. Finally it said, "There is a great deal of uncertainty associated with this procedure."

Kelric thought of the shadows in his mind. "I'll take uncertain life over certain death."

Another pause. Then the Glint said, "I understand, Captain."

Kelric tried to relax. "Well, let's do it." He fired the photon thrusters....

Nausea surged over Kelric until he almost lost the breakfast he had eaten a few hours and who knew how long ago. The screen in front of him showed Diesha swelling into view like a ruby and turquoise jewel.

He struggled to clear his mind. "Glint? Why did you wake me up?"

"We're going to disintegrate," the Glint said. "I thought you would want to know."

Kelric swore. "Get us down as far as you can before the plane falls apart."

"Re-entry initiated. I've activated my emergency beacon."

Kelric wondered if they had come back to a time when anyone existed to pick up that beacon. "Can the reactor shielding survive the crash?"

"Yes."

Good. The reactor wouldn't splatter all over the landscape. He hoped the same was true of him. The Glint, designed to be as light as possible, didn't even carry an escape capsule to protect him when he ejected. "Will you be able to slow down enough for me to eject?"

"I calculate a 53 percent probability of it."

Well, that was better than zero. Even if he didn't make it, at least the Glint's mind would survive. The computer was better shielded even than

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the reactor.

Kelric touched the console. "Jessa and her team will have you fixed up in no time."

"I don't think that will be possible," The Glint almost sounded subdued.

"Why not?"

"When we reinverted, I created a cybershell for your mind. It damaged my systems."

"A what shell?"

"Cybershell. I ran your brain as a subprocess of my own. Your mind wouldn't have survived reinversion otherwise."

Kelric whistled. "That's impossible."

"Not completely. However, it did leave me unprotected during reinversion. By the time we crash, my functions and memory will be degraded past recovery."

No, Kelric thought. No. "You killed yourself so I could live."

"I'm only a computer."

"A computer, yes. 'Only,' no."

"We're disintegrating."

Kelric spoke softly. "I won't forget, friend."

Then he ejected.

He went out the top of the plane, shooting upwards as the Glint fell away from him in pieces. Windblast buffeted him so roughly that he almost blacked out.

Then he began to fall. He tucked his chin to his chest, held his legs together, and crossed his arms while he tumbled through the air. Silence surrounded him and clouds covered the landscape below. He tried to look at the altimeter on his arm but the numbers blurred.

It took a moment for Kelric's groggy brain to comprehend that he had used up even the air in the emergency tank on his suit. He was suffocating. He clawed at his helmet, his fingers scraping across the face plate. Darkness closed around him, warm, inviting. . . .

A blast of cold air slapped Kelric awake. His helmet had opened and the timer in his suit was going off, triggering the release of a parachute. It jerked him so hard he thought his arms would rip off his shoulders. Even with his computer in his suit controlling the parachute, he feared the inflation shock would tear him apart.

Then, mercifully, the buffeting eased. His survival kit deployed, its life raft dangling from his suit like trailing seaweed waving in an ocean of air. Clouds closed around him and he fell in silence through a wet mist that ate away at his sense of up and down, right and left.

Gradually Kelric realized the world wasn't silent. A rumble throbbed below him. As he fell, the growl swelled into the roar of waves hitting land. Even when he sealed his helmet he still heard the thundering voice.

There was no warning before he hit water. He plunged into it, his limbs tangling in the parachute's suspension lines. As he struggled to free himself, he plowed into sand. With a huge kick he shot back out of the water, breathing the few moments of borrowed air in his suit.

Kelric pulled free of the parachute and grabbed the life raft. But as he opened his face plate a wave smashed

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into him, filling his suit with water instead of air. Another wave came, and another, and another. The breakers tore away the life raft and rolled him over and over, his lungs straining while he struggled not to gulp in water. Another wave hit, followed immediately by a second, and he knew if he didn't get air within the next few seconds he would pass out.

His feet scraped the bottom for only an instant, but it was enough. He shoved against the sand and shot upwards, clearing the breakers long enough to gasp in a breath. Then he was back in the water, fighting the waves. He touched sand again, again, again, and he was stumbling up a slope, waves crashing around him in a frothy turbulence of suds.

Kelric staggered onto the beach, wading out of the waves and mist into watery sunlight. Ahead of him a hill sloped up to a road—where a hovervan with flashing red lights was slowing to a stop. As people jumped out of it, he heard the sound of an engine overhead. He looked up to see a flyer circling above him, its Space Command insignia gleaming in the sunlight.

A woman in a blue jumpsuit was running towards him, her shoulder-length hair glinting like copper. As Kelric sunk to his knees in the sand, people surrounded him on all sides. The woman dropped down in front of him, tears on her face. "You crazy man."

Kelric barely managed to croak out an answer. "Zaub. How did your hair grow so fast?"

"Six months you been gone." Jessa's voice shook. "Six months we been thinking your hide was finished."

"I came back to get the money you owed me."

She pulled him into her arms. "Welcome home."

Kelric hugged her back, unable to respond as sobs tore out of him.

The broadcasts that aired in the weeks following his return made him out to be a bigger-than-life hero. Over and over they showed the scene of his parents embracing him, the son they thought they had lost, his breathtakingly beautiful mother with tears streaming down her golden face. Space Command took advantage of the good public relations and paraded him around in his uniform, keeping quiet about that fact that they also temporarily took him off flight status and sent him to a therapist. Kelric went where they told him to go, stood where they said to stand, and tried not to look like an idiot.

All of the reports went on with great enthusiasm about the dramatic moment when he wept on the beach for the joy of seeing home again. Kelric let them say what they wanted. He knew, deep inside where suppressed grief had once crippled his heart, that the healing tears had been for Cory. ■

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BIOLOG Jay Kay Klein

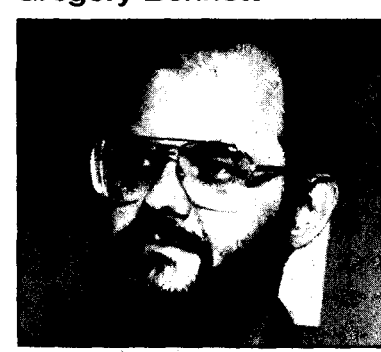
Gregory R. Bennett is one of the many contributors that have been SF readers, SF fans—and engineers. This combination is guaranteed to make you want to write SF, though not everyone succeeds. Greg's dad was a pastor skilled in building up congregations and moving on to trouble-shoot elsewhere. Raised in a variety of places, Greg particularly remembers Alexandria, VA and the day he heard the Russians had sent up a satellite.

He finished high school in Galesberg, IL and majored in physics for two years at Knox College. Hearing grads couldn't get jobs, he transferred to the University of Illinois as a major in aeronautical and astronautical engineering, just in time to encounter the aerospace industry's catastrophic crash. Still, he was able to select from several job offers, heading for Boeing in Seattle along with a brand-new wife, who later was to become vice-chairman of the 1992 world SF convention.

Their attendance at a first worldcon in 1976, with Robert Heinlein as guest of honor, changed both their lives. Greg founded an L-5 Society chapter, the Northwest SF Society, and the giant Norwescon. The first person he met at the 1976 worldcon was Jerry Pournelle.

Greg continued with a series of jobs in the space program. Currently, he's with McDonnell Douglas at the Johnson Space Center in Houston as manager of extravehicular activity development for the space station. Time for writing has been seriously curtailed, but papers still pour out on topics like supersonic transport handling, dynamic control theory, and space operations analysis.

Gregory Bennett



A "Probability Zero" in the Mid-December 1992 *Analog* was followed by three stories, culminating in this issue's cover story. Greg's love for SF centers around the hard-science, en-

Biolog continued on p. 160

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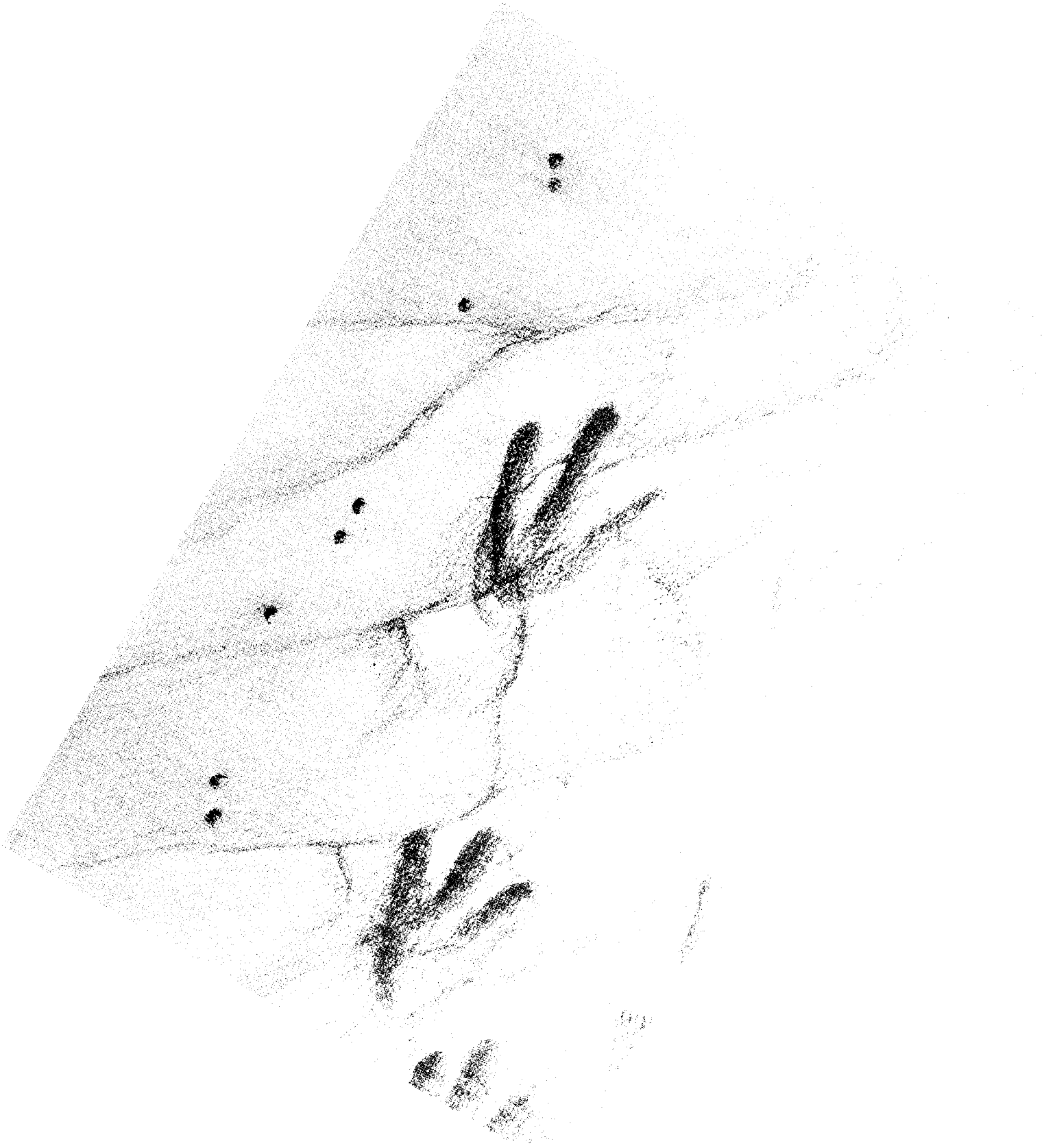

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Bud Sparhawk

IRIDIUM DREAMS

Many humans dream of immortality but few can grasp what a difficult goal that is.

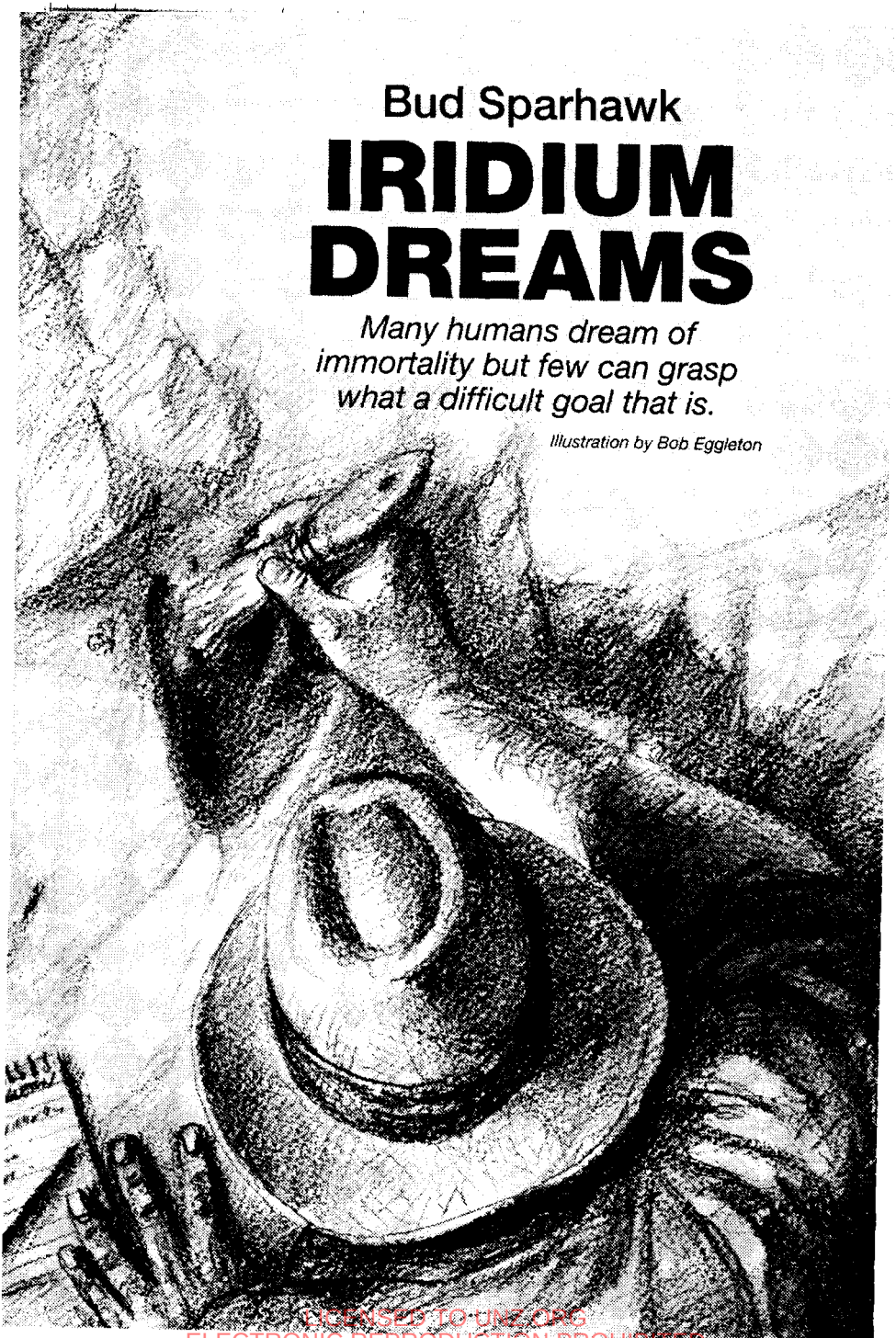

Illustration by Bob Eggleton

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The winter's weak Sun gave scant warmth at this altitude, where bare rock and a few sparse grasses stretched as far as one could see. Down the slope from the camp, just beyond a scattering of scarp frost-shattered from the cliffs above, the natives were carefully scraping away the detritus of stone to reveal the sedimentary layers beneath. He could hear the light babbling of their Indian accents although the distance and the wind prevented any understanding of their words. They were probably talking about their families, the lousy food, and the crazy assortment of foreigners that chose to spend their time and money on an Argentine mountainside picking away at rocks and boulders.

Perhaps a few of them, experienced in the work from previous expeditions to this lonely place, understood the significance of the bones that they occasionally uncovered, and would explain it to the newer ones. These were the remains of great animals that roamed the Earth no more, so incredibly ancient that they predated the arrival of humanity's most distant ancestors. Would the more religious among them think it blasphemous to suppose that others predated God's creation of Adam and Eve? Or would they take the more sophisticated approach, favored by enlightened fundamentalists, that the seven days of creation were God's days and not the puny measures known to Man? Either way he expected no trouble from the crew. The natives were known to be hard and reliable workers, not given to drink or brawls, two of the main problems he'd had in other expeditions around the world.

He remembered the long climb they had made to reach this remote site far from any evidence of civilization and the works of man. The bones they were digging had made a longer journey, moving from the flat Jurassic landscape to this place through a combination of accidental sedimentary capture and tectonic forces. Would the works of man make a similar journey through the ages, he wondered? Angelica had pondered that same question.

Once they had been sitting side by side on a rock overlooking a similar valley when Angelica had noted the smoke from a distant village and pointed it out to him. It was a tiny dot on the landscape, barely significant in the surrounding grandeur. "Did you ever think of what our analogues would think in, say a few hundred million years or so, when they sit in our place?" He twisted around to see if she was joking. "I mean, if we all disappeared what would they find—think about it for a minute. What would the fossil record show?" Her voice was serious.

"Have you been reading Bakker again?" he asked with a laugh. The serious look on her face told him this wasn't an idle question. He thought about it for a moment. "I suppose they'd find some buildings, artifacts, stuff like that."

"No, most of those things would disappear or be rendered unrecognizable within a few million years or

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so. Look at what we have to deal with; a hundred thousand years squeezed into a few inches of detritus for the most part. Think about that: It's less time than humanity has been around, much less than any of our so-called civilizations. Hell, look how fast an abandoned road disintegrates into hardpan and bush! Look at what the ancient cities are like after a few thousand years! Think about the years like a paleontologist, not an archeologist, *Doctor*."

He tried to picture himself as a remote descendent of some small animal of today, not a mammal—a bird perhaps? Yes, that would be justice. The descendants of the dinosaurs rising to claim their rightful place once again. Now, in that frame he tried to piece together that creature's view of the mammal's world—the eons tumbled together so that precision was within two or three million years or so—my God, that was less than the time man had existed! He looked at Angelica with renewed respect, "We wouldn't be in the record at all! We wouldn't leave a mark!"

Angelica patted him on the back. "Very good, *Doctor* Adams. Go to the head of the class." With that she rose and headed back to camp. Apparently she was once again off on one of her hare-brained ideas. Jack shook his head in wonder at the things she came up with. Good thing he was there to keep her on track.

There had been a bite in her use of his address. Maybe she was still smarting because he had once again dragged her from working on her own thesis to help him on his field trip. But, he mused, he needed her with him; she was his best helper, with a keen eye and steady hand.

"Buenos dios, Señor Doctor *Ahdhams*," his local supervisor, Martin Ricardo said in his broad pronunciation of Jack's name. "What may we expect today? Some *fantastico* rare specimen, perhaps?" Ricardo, as the University's local representative, no doubt knew that Earth-shattering discoveries were not the reason for these excavations; paleontology didn't work that way. This dig was simply another step in the careful assembly of the small facts that would later contribute to a larger body of knowledge. Research on the dinosaurs progressed slowly, each excavation broadening the sea of information that all could swim in to uncover relationships and feed the formation of theories that, when returned to the sea, would sink or swim on their merits.

And how vast was that sea: The age of dinosaurs stretched for over one hundred and sixty million years! Based on the current rates of speciation and what pitiably small amount of knowledge they had of climate and conditions over such a vast span of time, literally millions of species had arisen, competed, evolved, and died. Of those species billions of their members had trod the Earth, feeding and becoming food for others. The heavens, the seas, and the land were abundant with their numbers, vast beyond imagining. Almost no patch of dirt was untouched by their bodies, no spot that didn't know a death

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or birth. And of those incredible numbers what remained as a baseline of data—a few thousand bones of a few hundred species; a tiny, nearly insignificant sample of the plethora of life that had gone on in that time span. How like mankind to try to piece together that huge tapestry of knowledge, to define such a span of time from the pitifully few scraps that remained.

He glanced down the slope toward the workers once again. The scarp they were excavating was once the edge of a vast shallow river on whose mud flats the dinosaurs of the late Jurassic once roamed. A mile away, on another mountain that he had visited years before, he had seen the tracks of these creatures marching up the cliff toward the heavens. He remembered how that expedition had come to its tragic end, and how he had vowed never again to walk these hills, such was his despair.

The whole community had been excited about Wilkerson's find, discovered when an overburden of granite had fallen away to reveal layers of hardened sandstone with their imbedded tracks high in the Argentine mountains. If Wilkerson hadn't been visiting the area he never would have seen and recognized the formations for what they were—a perfect set of mid- to late-Jurassic footprints. And from where sections had fallen away Wilkerson could see that there were multiple sets, stacked upon each other like pages in a book, or frames in a hundred-thousand-year movie. Apparently some periodically drying up late-Jurassic pond had occupied this site. The animals that came to drink at its shrinking margins left their footprints in the mud and sand, footprints that were later filled and covered by the blowing dirt and runoff sediments.

When they had heard of Wilkerson's discovery he had been building his reputation in the early Maastrichtian period. The Maastrichtian was the time preceding the catastrophe that had abruptly ended the Cretaceous. He had been trying to isolate what, if anything, had happened to the erect, bird-like bipeds of the troodontids family when Angelica had brought him the news from the Internet.

At Angelica's insistence they had joined Wilkerson's group during a break in his grant funding, and, honestly, a need to escape the frustration of scarce data on the Maastrichtian. He also needed to get away from the tedium of his own studies, the labs, and classrooms. Every time he went into the field and discovered a bone or a fragment he felt the same joy that Marsh and Cope must have experienced when they established the major bone quarries of the western United States. It would be a welcome diversion. He agreed to go for the season; "Until the snow flies," he said to her with a laugh.

Wilkerson planned to peel layer after layer of tracks off of the mountainside, preserving a series of time frames of life on the Jurassic plain. Nine scientists, plus their work crews, had set up a camp below the cliff face and erected massive rails

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and pulleys to guide the slabs of rock down to where they would be carefully separated, plastered, and then packed for shipment back to the five facilities who waited to examine them. Lockley, for example, had asked for a few of the deeper slabs, hoping to glean more trackways behavior from the earlier periods to extend his own work.

Wilkerson had been impatient to complete the work, pressing his schedule to accommodate a promised series of seminars. Against Jack's better judgment and advice he had drilled the cliff and used low yield explosives to fracture the stone encasing the slabs. Some freak accident, an unforeseen fracture in the stone perhaps, had sent the entire cliff tumbling onto the work site carrying the scientists, along with their precious tracks, into the valley below. Only Adams and the others who were near the tents above the dig had survived.

Memories of the trip back down the mountains without Angelica, the meetings with the trustees of the university, and the strained retelling of the tale to each of the families were blurred together in a haze of pain that he would just as soon forget. Better to block it out, to continue with his work.

With a shake of his head he brought his thoughts back to his present location, which also held an interesting trove from the same period. Apparently this area had been a delta for a river, a storm formed delta that had not had time to settle and harden before a number of creatures had tried to cross it and become entrapped in its soft texture, sinking down to suffocate and die. Later layers of silt washed over the site and sealed it away. In time the river no doubt was submerged by the inland sea, since the climate of that time was in transit from arid toward warmer, less seasonal variations. The site was like a photograph of an instant of time; unsullied by later deposits that too often mixed the bones of several eons together. Instead they would see only those animals of this one area over a period of a few years at most.

It always amazed him how the soft mud had become rock and survived while anything built upon the rock had disappeared. It contradicted humanity's insistence on permanence, building their cities and buildings upon the unyielding rock in their striving for posterity. That too, had been one of Angelica's crazy ideas; that the only thing surviving would be a scarce fossil record.

"Did you ever think about the paleontological results of our civilization?" she had asked one night while both were immersed in their databases, seeking some crumb, some tiny fact that would unlock new trains of investigation; his for his loved Maastrichtian and she for her thesis. "Aren't our depredations of the environment going to show in the record. Won't there be a gap in what we leave?"

Jack saved the file he was working on before answering her. Angelica always came up with these off-the-wall questions that appeared to have noth-

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ing to do with her studies. From experience he had learned to humor her. "What about diversity in the fossil record?" he asked wearily.

"Well, the fossil record would still show the demise of the dinosaurs and the rise of the mammals would still be there. I doubt that we'll ever dig up every site. Let's see, they'd find increasing diversity as the survivors populated every vacated niche in the ecosystem created by whatever wiped out their predecessors. I was thinking that about the time that humanity arose the number of skeletons would decrease."

Jack looked at her. "Why in the world would you think that?"

Angelica pushed on, Jack was so obtuse at times, almost resistant to new ideas. "Think about it. They'd find the remains of the early mammals, giant sloth, buffalo and maybe a few apes. Ha! They probably wouldn't be able to differentiate between the remains of a gorilla trapped in some tar pit and a miner buried in some deep mine."

"I agree. They probably couldn't tell the difference between them, especially if they had to work with fragments instead of whole skeletons, like we do."

Angelica continued as if she hadn't heard him. "Early man managed to wipe out most of the large land animals and then domesticated the few that were beneficial. None of the remains would be in the fossil record since they'd be completely consumed for food and other things. Say, maybe that's what happened to the dinosaurs!"

Jack was incredulous. "So are you saying that the avenger was just dinosaur hunger carried to extremes? I don't think that's a very good parallel, Angie. Besides, it lacks evidence and evidence is the proof of any theory. Really, I wish you'd stick to your studies instead of coming up with these crazy ideas. You'll never get through otherwise. I'll bet that your advisor will tell you the same thing."

"Thank you, *Doctor* Adams," she replied frostily, emphasizing his newly won title. "And I suppose that means I'm just a poor dumb grad student who lacks your clarity of thought." She locked the door behind her as she left.

That night he slept on the couch in the living room. Sometimes he just couldn't understand her; didn't she want his help?

Jack assisted the workers in pulling away some of the tailings from the six square meters they had excavated the previous day. They had to penetrate this hard pan before they could get to the sedimentary layers below. It was hard work that soon had rivulets of sweat running down his back and arms despite the cool air. He wished he had kept that damned hat Angelica had bought him. She was insistent on protecting his skin from the effects of the Sun, telling him that his pale red hair was a sure sign of susceptibility to skin cancers. Hats, that's how he had first met her.

Angelica had gotten her degree in paleontology at Maryland during the hard years, when grants were scarce

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and corporate benevolence non-existent. She had paid her own way the last two years, after splitting with her ex, by working as a waitress and barmaid in nearby Riverdale. After a few hundred for books, plus tuition, rent, and upkeep on her old Buick Century with its rebuilt engine and failing suspension, she had barely enough for food. Thank heavens she could get the freebies on the nights she worked, although it was often pizza and a beer after closing.

Survival and passing grades were all she was after during the school year. It was the summers she lived for, the summers when she could sign on with Chicago or Brigham Young for a dig somewhere in the west, maybe Colorado or Arizona. The meals were provided, along with luxurious (ha!) camping facilities and some of the most interesting companions she could hope to find. The only thing she had to provide was transportation, and that was cheap with all of the summer deals the airlines offered in the depths of winter when business was slack and competition high. The summer of her junior year she had spent the entire three months with a dental pick scraping a jaw bone of a Coelophysis out of the hardpan, while the Sun overhead turned her brown skin the color of well-aged leather. That was the year before she learned about the dangers of skin cancer and started using blockers and a large hat she had ordered.

The hat was a large blue thing with a wire rim that allowed it to be folded up into a small circle of cloth. When she twisted it in her hands the wire would unfold and form the edge of a brim about two feet in diameter. She had been so entranced by the way the hat folded into itself that she felt that she had to demonstrate it to everyone in the camp. Jack had been sitting at the next table at the time, just another new face among several who had arrived earlier that morning while she was out at the dig. Jack's graduate school thesis had won him a place on the expedition, all expenses paid and a salary to boot. He was just one more in an endless line of visitors to the camp. Most were visiting professors paying courtesy calls, or collaborating with one of the resident scientists on some seminar or paper due later in the year. Seldom did one of those worthies deign to acknowledge the poor grunts on whose backs and eyesight their reputations rested.

Angelica had been describing the hat's action to her neighbor and began to pull it from her vest pocket when it snagged on a button. TWANG! The wire expanded the brim suddenly, making the blue hat fly to the next table, strike a glass of juice and spill it into Jack's lap. Angelica reached to recover it, coming up out of her seat to do so. Her legs struck the edge of the camp table as she rose, lifting it and scattering the contents in every direction. With a great deal of cursing and scrambling, Jack, Professor Phillips, and Carolyn rubbed napkins vigorously at the mess on their clothing. Angelica grabbed her own napkin and began mopping and rubbing vigorously at the wet spot on Jack's trousers, put-

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ting one hand behind him to hold him in place as she worked, oblivious to his struggles.

"Please, I can handle that myself," he said and started to turn away. Angelica pressed down harder, trying to eradicate the stain left by the juice, not paying attention to its location until she suddenly became aware of what was happening and drew back, "I . . . I . . . " she stuttered, turning a dark umber with embarrassment.

Jack had grabbed the napkin from her hand and held it to the spot, leaning forward to do it and hide his reaction to her ministrations. "Remind me never to get near a hammer that you're swinging," he said. Phillips had come forward then to do the introductions.

"After her help, I think we've gotten to know each other quite well," he said with a twinkle in his eyes as he took her hand and shook it, "and we shall know each other better in the weeks ahead. I'm your new boss."

The anticipated retaliation after Phillips left for a seminar in New York and left Jack in charge kept Angelica hard at work for the next two months. Certain as she was that he would find some particularly nasty job for her she worked ten times harder than normal, finding chores on her own so that he could not squeeze in one extra task. By the end of the season she had dug more, found more, and helped more with the cataloguing than any of the others; all of which threw them into constant contact.

Nobody was surprised when Jack asked her to come to Utah to finish her graduate studies, and managed to find her a place not far from his own. Within the year they were living together. She followed him to Chicago where he would teach in the paleontology departments while enrolled in their doctorate program and married him three years later, right after his thesis was finished and she could begin her own doctoral studies.

The Sun had climbed higher in the sky until it was nearly overhead. Jack needed a break in routine and left the sorting tables to scale the heights above the camp, looking for some more signs of the same layer of deposits that held their attention. If the geology of this ridge were the same as the one back on Bacon Hill in Wyoming, there should be some exposure of the layer on the back side, where the overburden had worn away. Below the camp the layer ran at a slight angle away from the contour of the mountainside. Extrapolating that angle would mean that if there was a rill cutting the face then the same layer would be exposed without having to dig down. And there might even be some fossils embedded in such a layer, were they lucky enough.

But after an hour of searching he concluded that the mountain was a solid block and only continued digging would expose its ancient secrets. He settled back against a rock and opened his pack. Inside were two "chocolate" energy bars that looked and tasted like a diabetic dinosaur's turd. Nevertheless they provided the fuel that the morning's work had depleted from his body. He took a swig

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of the tepid water from his canteen, wishing it were a cold beer. Angelica had always wanted cold beers when they were miles away from any, and ignored them when they were available. It was one of her little inconsistencies that he loved.

"Did you find what you were looking for?" he'd asked as he slid down beside her during a break on his African expedition soon after their marriage. He had convinced her to take a break in her courses to accompany him. She'd only miss a semester. "I saw you leave the camp and figured that you might hurt yourself, clumsy as you are." His warm smile took the sting from his words. Her accidents were a private joke between them, a memory of how they met.

"No, I just wanted to look around to see if there was anything else we had missed," she replied. "It must seem pretty stupid. I mean, the advance team went over the topos and ground pretty thoroughly before we got here, didn't they?"

"Well, yes. But don't let that stop you. Bakker went over the same ground a hundred times before he noticed the first tooth. I don't believe that we're any more thorough. Look around, no telling what you might find."

Angelica squinted at him. "Are you humoring me?" she asked. "Now that I have my degree I'm more than a gofer and a strong back, you know."

Jack held up his hands in defense. "Don't bite my head off! What's the problem? Was it something I did?" Usually her minor rebellions were the result of some unintentioned slight on his part.

Angelica shook her head from side to side. "No, damn it! It's just that I need to feel the excitement of a find. This tedious, careful excavation of some bones that more than likely were identical to those dug up at a dozen other sites around the world just doesn't have the appeal that it once did." She rose and dusted her hands. "Jack, wouldn't it be wonderful if I could find something no one had seen before, something that would shake up the musty old profs? Wouldn't that be worth all the sacrifices we've made?"

Jack considered. Her chances of finding something like that were practically nil, nada, zip! He'd learned that paleontology was a science of care and cautious development, not one of dramatic discoveries. Hubris, that was the Greek word for what she was feeling; overweening pride in her own abilities.

"Maybe a healthy dose of humility is what you need," he suggested and pointed back at the dig.

"Maybe," she replied with a wipe at her forehead. "That, and a cold bottle of Anchor Steam."

After lunch Jack settled back in his camp chair and gazed across the valley at the distant mountains. The green of the deep valley turned a hazy blue by the distance. It was always hard for him to believe that when these bones were roaming the world all of this was arid flat land and the odd site they uncovered a damp pond or stream where the remains would

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be buried and protected by layers of sediment. How many millions of years did these bones lie peaceful and still while the sea waxed and waned above them, sending its own load of detritus to cover them. And all the while, through the tens of millions of years the land itself wandered south from the equator until tectonic forces tilted the former plain into this range of young mountains.

The Earth still wasn't through with moving her continents around. In another hundred million years or so North America would be sundered by the sliding Pacific plate and the Middle East would be crushed by speeding Africa's northerly travels. Where would humanity be then? What would remain of all their mighty achievements? She had asked the same questions at one time: Would humanity's much vaunted intelligence leave a mark?

Angelica was manic, pacing the room with a mad passion that only the truly involved can achieve. She was reading from her notes, preparing for the arguments that her reviewer would surely throw at her. Jack remembered that this was the hardest period for the doctorate thesis; convincing the reviewer that your subject was worthy of pursuing and within the realm of possibility.

"The grim destroyer, the black avenger, whatever you called it, the scourge of Earth's ecosystem returns every hundred million years or so to give some new version of life a chance to achieve dominance. Whatever had killed the trilobite had returned to wipe out the population of the Triassic and then again to eliminate the dinosaurs. Everywhere the deposits of iridium proved contemporary with the great die-out of those life forms, giving the small, scavaging animals a chance. What was the avenger? A vagrant asteroid, a comet, or a speck of antimatter? Whatever it was it had utterly destroyed the greatest beasts the world had ever seen.

"But that wasn't what happened in the late Jurassic time frame," she continued. "The climate was changing so that the flowers and seed-bearing plants that could stand the warmer weathers were replacing the dominant forms that had evolved in the arid early Jurassic. Along with the warming climate, the seas were advancing, and the land was becoming a marsh. Most believe that the late Jurassic die-off was the result of this combination."

Jack looked at her with some surprise; Angelica didn't sound sincere in her statement of the accepted theory. "You have some other ideas?" he prompted.

"Look, I'll admit that it was a tough period for life adapted to the arid plains. Everything had to evolve to fit the new conditions. Large bodies, which helped survival when there wasn't abundant water around to support it, became unnecessary in the marshes. Storing water in the body became more of a hindrance than help when ponds and lakes were abundant. And the increasing humidity and warmth opened up lots more ecological niches for certain species.

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But that, in itself, couldn't account for the wide-spread extinctions."

"Lots of niches closed off when the seas rose," Jack added. "It was a period that encouraged rapid evolutionary change."

"Yes, yes," she said eagerly. "Climatic changes produce evolutionary changes; we all know that. Remember, it was climatic conditions that forced our ancestors out of the trees," she remarked. "Just as we had to adapt to finding food on the ground or become better apes as the jungle shrunk."

"So everything in the ecosystem had to adapt quickly; change their form or die out. They had to make use of the new resources. What's your point?" So far she was simply rehashing old ground, well established facts.

"Well," she answered, "the theropods adapted by becoming better and faster predators, splitting into several groups. Most of the other families diminished in size as they marched into the Cretaceous period. Somewhere along in there the ornithoids had turned themselves into primitive birds and became the ancestors of our present day versions of dinosaurs." She took a deep breath and then said in a rush, "Isn't it reasonable that some of them might have developed intelligence as a survival mechanism? I mean, conditions were somewhat the same as those that produced us, weren't they?"

There were more surprises in her than he had ever imagined. Her mind seemed to make associations that he had never considered. Perhaps there is some benefit to knowing too little about the field, or maybe her anthropology courses were more recent than his own. He smiled; so quick, so smart. He'd been wise to marry this one. "Could be, but where *is* the evidence? We haven't dug up a Cretaceousmobile nor found the ruins of some vast Mesozoic metropolis as yet."

Angelica flushed with dark embarrassment as if it was a stupid idea and he was making fun of her. But she had never backed down from an argument once she'd taken a position, and he wasn't going to intimidate her now. "Most structures wouldn't survive. Besides, cities are always built on seaside and along rivers for good solid reasons—transportation mostly. Those areas would be subducted or ground down in a hundred million years, if they ever existed. Just because you haven't found them isn't proof that they couldn't exist!"

Instead of a counterargument Jack Adams just looked at her with a bemused expression on his face. "Is this a repeat of your crazy idea that the die-back of the large animals was because the herds were hunted to death?" he asked with a chuckle.

Angelica tossed a throw pillow at him. "That was one possibility, but maybe domestication was another. Yes, domesticating the herds would come later, after the larger ones became too scarce to be a dependable supply." She clapped her hands with sudden excitement. "Think of it, Jack. Can't you see a few troodontids racing along the sides of a vast herd of . . . what? Triceratops? Pachyrhino-

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saurs? Hadrosaurs? Or some special species that we haven't discovered?"

"Nice thought, but based on our own history there wouldn't be any fossil record of a domesticated animal—too much use can be found for all the parts to leave any for posterity. No," he said, shaking his head, "Unless somebody finds a dinosaur bone with a chipped point embedded in it or some artifact that we could recognize as coming from an intelligent being, any thoughts of a dinosaur civilization are sheer fantasy."

Angelica visibly wilted. Jack was right. In paleontology the proof of a theory was always in the fossil record and nowhere had anyone found even the slightest evidence to support her idea. It was just that, a fantasy that would get her no nods of approval for a thesis subject. She sighed as they prepared for bed that night, the image of the troodontid herdsmen still vivid in her mind.

"I understand that west of here you can still find tracks from this era," Ricardo remarked casually as they sat around the campfire sipping on a bottle of Cap't Morgan and drinking strong Columbian coffee.

"Not any more," Jack replied curtly. Let Martin find out for himself what had happened. He'd just as soon not have to go through the explanations again just to satisfy someone's curiosity. "They were all destroyed years ago, in an accident."

He looked again at the verdant mountains and tried again to imagine the arid world that the tracks had represented. Some version of a modern plains wouldn't be right. Angiosperms, the flowers and trees came later, in the Cretaceous period. Back in the later Jurassic the plain would have been sparsely dotted with ferns, ginkgo trees, conifers and cycads. The grasses hadn't come into being to cover the land so their niche would be filled with some sort of low ferns, maybe even seasonal mosses.

"*Madre de Dios!*" Ricardo exclaimed, spilling some of the coffee onto his leg. "I remember it now!"

Adams looked at him. Martin was wearing an expression he had seen before; obviously he'd finally connected his "Señor Doctor *Ahdhams*" with the earlier expedition. "Yeah, we lost seven people in the avalanche. I was one of the lucky ones."

"Your wife, too. I am sorry to bring it up, Señor Adams. Please forgive me, but why do you choose to return to Argentina, and a place so close to the accident?"

"It is the only place we can find such clean evidence of this part of the Jurassic period," Jack replied flatly.

Ricardo shifted uncomfortably in his chair. "Ah yes, so I understand. But your papers which I have read completely, deal with another period. You are trying to finish the work your wife began, perhaps?"

Jack looked at him: What was he to say? "Sure, I threw away my entire specialty and all of the grant money to study this little slice of time." If he admitted to something like that they'd think it was survivor's guilt. "A natural reaction," everyone would say. "Such a pity for the Cretaceous group, but quite a boon for the Juras-

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sics," his research associates would rumor. Let them think what they would; what else could he say but agree with them? It was easy and reasonable. It was also dead wrong. "Something like that," he replied.

Their argument had been short and brutal. The chance to work on the new Chinese finds was the opportunity of a lifetime. The previous evening he had learned that some workers digging a new pipeline in the Chang Hau valley had uncovered strata of almost perfect Maastrichtian fossils, along with a host of preserved plants and insects. Apparently a huge mud slide had swept down the ancient mountains into a valley and entombed everything in its path, burying a complete ecosystem in situ and preserving it for ages. He could practically taste the facets of life that those strata would reveal and hear the acclaim that would come to those who were first to publish the findings.

But Angelica had been insistent that she stay with Wilkerson's group as they peeled away the layers of Jurassic tracks from the mountainside. "Damn it, Jack. You agreed to stay with this expedition for the season. You promised me!"

Yes, he had. For more years than he liked to remember she had interrupted her own pursuits to accompany him on trip after trip, examining late Mesozoic turds and bones until she said she was sick of the sight of them. And she had helped him write article after dull article about his latest findings, typed the grant requests late into the night, and had sat with him at the Internet terminal as they pored over the electronic dialogue of academics in fifteen countries, trying to extract something that would illuminate some aspect of his own researches.

And all the while she tried to stay current with her own era of study, reading long after they were abed to try to stay abreast. "I'll support you the same way," he'd promised. "Once this grant is over we'll start working on getting your own research going." But that day never seemed to come.

And when she had announced that come hell or high water she was going to Argentina with Wilkerson to look at some tracks he had found, he had agreed to put his own work aside and travel along.

But that was before he heard about the Chinese find. "But if I don't get my name in and let them know I'm interested, I might have to take a minor role. I don't have the reputation to win it without politicking, you know. My work is just starting to get recognized, and even then I have to share the credit with Benson and the others in the department."

"You are one egocentric son-of-a-bitch," she replied hotly. "I have invested more damned time in your work than you could pay back in years. I have subordinated my own career for you on the promises you made that we would be equal, helping each other! Now as long as you have nothing better to do, you agree to come along and help me . . . and as soon as it isn't convenient you want to go rushing off to the other side of the world to look at some more

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damned Maastrichtian turds."

"That's not fair! This isn't some trivial find; it's a major study field. This will tell us more about what life was like before the avenger than anything we've seen before. I have to be a part of it! And that's a hell of a lot more sane than pursuing some of these crazy ideas of yours that won't go anywhere!"

Angelica looked as if she had been slapped. When she next spoke her voice was as cold as ice. "If that's all you think of me then go, damn it! Go, and don't look back, because I'm not coming with you! Not now, never again." With that she flew out of the tent and down the hillside to help the team slaver some more plaster on the last set of tracks they had removed.

After bidding Ricardo good night Doctor Jack Adams, respected scientist and field worker, poured himself another tot of the Cap't, extinguished the light and laid back on his cot. Each night he tried to still the layers of memory in his head. Tried to stop them from unfolding as he dug through the horrid afternoon when the fractured rock had finally given away.

In his mind's eye he could still see the layers of sediment sliding away, one after another, to tumble into ruin against the outcropping where the camp had sat and tumble into the valley beyond. He had stared fixedly at the eroding surface as it unveiled layer upon layer of tracks; heavy footprints of lumbering giants, darting birdlike marks of the racing allosaurs, and a hundred indistinct tracks made by creatures unknown and unknowable by man, all flicking away in a reverse fast frame movie going further and further back in time.

And the image that would stay with him until he died was the one of Angelica, standing amidst the devastation, untouched as hundreds of tons of stone shattered and tumbled around her, staring fixedly at the one slab that was peeling, sliding, tumbling directly toward the spot where she stood.

Had that particular piece of stone really held to the cliff face an instant longer than the others, or was that a trick of his memory? On its surface he could still recall the four sets of tracks crossing it diagonally. Four creatures had walked abreast across a drying Jurassic pond one hundred and fifty million years before and left an indelible imprint of their passage. The larger tracks were bipedal, with a four-foot stride. Beside them were slightly smaller tracks of the same creature, but deeper, as if burdened by a heavy load. To the other side were the tracks of another animal, padding alongside.

But it wasn't the tracks themselves that arrested his attention and at which Angelica stared as they hurtled toward her. Those tracks could have been made by any of a dozen species that had wandered that plain. What had drawn her attention had been the parallel tracks on either side of the four-footed creature and the odd holes to the left of the larger tracks. In a flash of insight she must have visualized a family group: Larger one leading the others and probing the

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ground ahead with a pole, the smaller one carrying its young in its arms, and some sort of tamed creature pulling a travois loaded with their possessions alongside.

And then the slab had disintegrated into a mad tumble of rocks and debris that swept Angelica away and out of his life forever.

Had he really seen those tracks or was it the terror of destruction and death that affected his memories in some strange way? The image was so clear, so persistent that he could not doubt his mind. The same interpretation had not come to him until months later, after his grief and his guilt had abated somewhat—and the epiphany of understanding that had accompanied it.

And so Doctor Jack Adams had foregone the late Cretaceous, his beloved Maastrichtian, the Chinese find, and come to this remote site to study the Jurassic.

In a way Señor Martin and his associates were right; it *was* to honor those that came before that he had turned his attention to this little sliver of time, eighty million years before the great Chinese find. But it wasn't Angelica or even the dead Wilkerson that he honored; it was those who had left that brief trace of themselves on the mountainside. He had to know what had become of those creatures and their descendants. Were they a failed line that soon died out leaving no further evidence of their lives? Or had an intelligent dinosaur civilization arisen and flourished in the early Cretaceous period, leaving no trace?

How long would an intelligent race last, anyway? A few hundred thousand years, maybe a million at most—and there had been nearly a hundred million years between the time those tracks were made and the latest great extinction. How many other intelligent species could arise in that period and what would be their fates?

Perhaps the great extinction wasn't the avenger at all but simply the effects of civilization creating an ecological holocaust that eliminated the dinosaurian legacy. Or perhaps, he thought whimsically, reminding him of Angelica, the distant descendants of those who made the tracks had loaded their iridium powered arks with the abundant life of Earth and left the small struggling creatures behind as they ascended to the heavens.

The last memory that crossed his mind before he surrendered to sleep's soft forgetfulness, the same memory that had haunted him in all of the years since, was of Angelica staring at the tracks that were to crush her . . . and smiling in triumphant wonder. ■

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THE ALTERNATE VIEW G. Harry Stine

ENERGY

The late anthropologist, Dr. Carleton S. Coon, observed, *"Man has been converting energy into social structure at an ever-increasing pace. As he has drawn more and more energy from the Earth's storehouse, he has organized himself into institutions of increasing size and complexity."*

Therefore, energy sources are important to us. Without them, we would immediately sink back to the days before our ancestors discovered how to use fire. That was the first form of natural energy mankind began converting into social structure.

However, we're constantly being bombarded by the wails of the doomsday soothsayers that we're running out of energy, or that we're using too much energy, or that we must go back to simpler energy sources because we're destroying the environment. Or all of the above.

I disagree vehemently with these doomsdayers on all counts.

The human race has never run out of energy and will never run out of energy. We may have been short of energy from time to time because of mismanagement of existing energy resources or failure to develop new ones to meet increasing demands. But we've shown ourselves to be smart enough to keep from suffering a real energy shortage. History clearly shows this to be the case, and historical trends are continuing even today.

In every instance in the past when we've been confronted with an energy shortage, the path to the solution was never backward to the use of a previous energy source except on a very temporary basis. The path has always been forward to the use of new energy sources.

When England began to run out of wood in about 1700 A.D., the English didn't go back to burning sheep or cow dung; there wasn't enough of it. Instead, they developed the technology to mine and burn coal.

In the middle of the nineteenth century, another energy shortage appeared. The market for whale oil and other animal-derived fuels for domestic heating and lighting expanded faster than the resources could accommodate. Demand exceeded supply. Petroleum, that sticky black liquid that oozed from the ground and was a nuisance to farmers in western

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Pennsylvania, was harnessed as an illumination fuel by A.C. Ferris, who had a lamp designed to burn this fuel without smoke or odor. But Ferris couldn't find enough naturally-occurring "Seneca oil" to satisfy the requirements of his customers. In 1849, another entrepreneur, Samuel M. Kier of Pittsburgh, was also selling for heating and lighting purposes the crude oil that seeped up from one of his salt wells along the Allegheny River, but he couldn't produce enough to satisfy the demand.

Then a bit of technological transfer occurred when George H. Bissell and Jonathan G. Eveleth of New York took an alternate view of the problem. They decided that the same derrick drilling equipment used to drive salt wells also could be used to drill for petroleum. They took into their partnership Colonel E. L. Drake who began to drill the first petroleum well along Oil Creek near Titusville, Pennsylvania, in May 1858. Over and over again, Drake struck only water. But he didn't give up. Let this be a lesson to technological pioneers: Don't be like the person who invented Preparation G. Finally in May 1859, Drake's crew under Uncle Billy Smith struck crude oil and their well flowed at the rate of 22 barrels a day.

The demand was greater than that, so more wells were drilled until the hillsides of western Pennsylvania were festooned with oil derricks. Today, the environmentalists would raise hell about it. But the resulting abundant and cheap supply of crude oil and the fuels and lubricants that could be refined from it, caused a changeover from whale oil to petroleum products. The environmentalists who are out to save the whales never mention that the entrepreneurial efforts of these early oil barons probably saved the whales then and gave Greenpeace something to worry about in the following century.

The abundant and cheap availability of petroleum has resulted in a worldwide civilization based on the use of petroleum for energy and the reallocation of coal usage for electrical power plants. Coal was phased out as a fuel for mobile vehicles such as railway locomotives and ships because petroleum has a higher energy content and is far easier to handle.

Can you imagine the old coal-fired ocean ships where gangs of men shoveled coal from one bunker to another that was closer to the boilers and finally into the fireboxes themselves, never seeing the light of day at all? A similar fate befell those who lived in the towns and industrial areas where coal was used as an energy source; they hardly saw the Sun through the coal smoke.

In all probability, you've never smelled burning coal. If you want to experience it today, you must go to eastern Europe where "classical technology" of the nineteenth and early twentieth century still runs things. Nor have you lived in the stinking smoke-filled air of the cities of only fifty years ago. Coal is now burned only in huge electric power plants where the emissions are unseen and unsmelled. But carbon-14 and other radioactives liberated by the chemical combustion of coal are still pres-

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ent in the ash along with carcinogenic materials with a half-life that is infinite as far as we know.

This is not to say that use and compatibility problems of some energy sources don't exist. However, because of engineering and technology coupled with entrepreneurship, we have a far better world than our parents lived in.

However, this has cost something. Thus, the cost of energy has increased. At what point will economics alone reduce energy consumption? It already has.

If you wish to encounter environmental air pollution today, go to New England in the wintertime. People there have fallen back two technological generations and are consuming their forests again. A nighttime drive along I-84 will permit you to smell the "nostalgic" aroma of thousands of wood-burning stoves. I guess the environmentalists are somewhere else.

Wood is a lousy fuel, but energy efficiency doesn't have anything to do with it. The caloric content of petroleum-based fuels runs roughly 19,000 BTUs per pound. The best you can wring out of plant-power fuels, namely the alcohols, is about 17,000 BTUs per pound. A 10.5% difference can break the competition. Economics and availability drive the type of fuel used.

I'm fortunate to live in a part of the United States where natural gas is available and cheap. It's a dandy fuel that heats my house and my hot water at less than half the cost of electrical power used for the same purposes. Furthermore, I have a natural gas fireplace that does *not* smell or produce biologically harmful emissions.

I also live in a place where solar energy can be used. Many of my neighbors have solar water heaters on their roofs. The capital costs are high. So are the insurance premiums because of such natural phenomena of the American West as hail. However, solar energy is thin stuff with low fiber content. You have to have a lot of equipment to catch a little bit of it.

Are we running out of energy? No. Back in 1977-1979, I was part of a multi-year NASA study to see if the "limits to growth" scenario would drive space utilization and industrialization. We had the world's best data sources at our command, and we used them. We looked hard to find shortages. We couldn't. I still monitor hundreds of data bases and sources to make sure the trends continue. They are. Room does not permit me to cite them.

I saw no solid data to support the limits to growth scenario and I have seen nothing that supports it today. We are not running out of energy or materials. The United States alone has the world's largest reserve of coal, enough to last this planet for the next 2 million years even at accelerated rates of consumption. The entire world has *known* reserves of 560 trillion tons of coal. Nor is there a shortage of petroleum, now or in the future. Twenty-nine serious forecasts of world petroleum reserves have been made since 1942, and eight of these have already been exceeded by known, proven, and producing oil

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fields. The United States alone was a reserve of natural gas amounting to 11.9 trillion cubic feet, enough to last 196 years.

The doomsday futurists remind me of the investment expert who predicted nine of the last two recessions.

However, we probably won't be burning coal or petroleum fuels in the future. Why? Politics. The shortage scenario was shown to be in gross error as long ago as 1978. Therefore, a new "rationale" has been developed by those who want to control access to energy resources as a means to exercise control over people. They're now trying to do that by telling us that the continued burning of fossil fuels is destroying the environment. Therefore, energy use must be restricted and controlled.

Again, the real data show no global warming due to carbon dioxide produced by burning of fossil fuels.

"Deadly acid rain," the result of oxides of nitrogen (NO_x) in the atmosphere, existed long before our present industrial expansion began. We're being told that we must cleanse the air of NO_x. How? If we shut down every internal combustion engine in the world, we would reduce the total NO_x by only 1% because biological action and organic decomposition naturally produce 99% of the NO_x in the atmosphere. Therefore, any attempt on our part to eliminate NO_x from the atmosphere—if we could do it—would cause irreparable damage to life on Earth.

So we have Science By Perception because it suits the agendas of those who crave power over people. Instead of yammering about shortages, they've shifted to an attempt to control the *use* of these resources to "save the planet." Herr Josef Goebbels was right: Repeat a lie often and it becomes perceived as truth. Environmental disaster stories make Page One; data refuting them occupy two column inches on Page 45.

Another way to control resources is to tax them, and they're doing that in increasing amounts, too.

Politicians and bureaucrats have been at this since ancient Sumer. No matter what the method, it's still the same old con game. I'm surprised more people haven't caught on after 5,000 years.

So we're in an era of political "resource management" that's a de facto energy shortage, albeit artificial. This creates an energy crisis.

Historically, any energy crisis has always driven a search for new energy sources that the politicians and bureaucrats haven't yet grabbed. And this search has always been driven by economics. If energy gets expensive because of "managed competition," rationing, or taxes, people begin looking for new energy sources.

Nearly two decades ago, Dr. Romualdas Sviedrys postulated seven historical lessons about energy. So that you, too, can start applying these lessons to what's happening, here they are:

1. The nature of an energy crisis changes with time. Three centuries ago, it was a matter of running out of wood and waterfalls. Today, it's the perceived environmental damage of continued use of fossil fuels.

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2. Forecasts about limits to growth are based upon specific energy resources and have assumed no future technical developments. Technology defines resources. Waterwheels made water into an energy source. Steam engines did so for coal. Internal combustion engines did the same for oil.

3. At the time forecasts of an energy crisis are made, inventors are already quietly developing the new technologies that will result in new energy sources within 25 years and will, within 50 years, largely displace the old energy technologies.

4. Current technologies completely miss the mark when they forecast how we'll work our way out of an energy crisis. For various reasons, they discount or neglect to consider the role that new technology will play.

5. Technologists prefer to improve familiar technology by a fraction of a percent than to gamble on a major improvement from unfamiliar technology. They manage to make marginal improvements in old technology just before it's made obsolete by new technology. This isn't unique to energy technology, by the way.

6. New technology is created on a shoestring, usually by individuals working alone. Many engineers worked to improve the efficiency of waterwheels while James Watt worked alone on the steam engine that would replace waterwheels. Daimler, Diesel, and Otto worked with their meager resources at the time when the steam engine was being marginally improved by teams of technologists possessing considerable financial backing.

7. In each energy crisis in the past, the solution has amounted to a "quantum jump" in terms of energy availability, efficiency, applicability, and concentration. This, in turn, has caused a jump to greater wealth and an improved life style for everyone.

If you heed these seven lessons of history, you'll see the emergence of the new energy technologies first and perhaps be able to profit by this. I seriously doubt that we will find one way to solve the current politically-created energy problems. We'll find several. However, one will have an overwhelming advantage over all the rest.

Contrary to the current shibboleths about the adverse environmental effects of using more and more energy, we'll keep on developing new energy sources with higher energy densities, greater efficiencies, and reduced environmental effects. Why? Because we must continue to create social institutions of increasing size and complexity lest we destroy ourselves. We may not be able to destroy the world, but we can probably destroy ourselves or set the human race back a few millennia.

What are these new energy sources? One of these appears to be a clear winner: hydrogen. In this regard, don't believe that so-called "cold fusion" is no longer in the picture. You might be surprised. But I'll leave it right there for the moment. I've probably stirred up enough controversy with what I've already written because many people "know" otherwise. We'll see.

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* * *

NOTE: Only one acceptable way exists to challenge a forecast: Put your money down and we'll revisit the forecast at some specific future date. So don't waste your time trying to argue with me. Let's get a third party to hold the promissory notes for hard cash, and, at an agreed-upon time in the future, we'll look again and see who was right, winner take all. ■

IN TIMES TO COME

One of the closest things to a universal characteristic of humankind seems to be that people everywhere assume that the customs and biases of *their* culture are representative of humanity in general, or at least *civilized* humanity. Those who have studied some history may recognize that people *used* to do things that seem barbaric now, but of course that's all in the past. Consider, for example, a quaint custom called "wergild," which just happens to be the title of P. J. Plauger's two-part serial beginning in our May issue. If you look it up, you may be aghast to think that our ancestors once did that—but you may also be hard put to refute Plauger's vision of how it could come back in our own not-too-distant future. It's a suspenseful tale that explores not only a disturbingly possible extrapolation of sociology and politics, but also the crucial question of how our next evolutionary step might adapt to existing societies. If you can do something hardly anyone else can, and your environment doesn't provide an outlet for your talents, you'll just have to create your own. . . .

That one will keep your attention, and I suspect you'll walk away from it with a quite different aftertaste than you expected. Meanwhile, G. Harry Stine, a veteran of many White Sands launches, provides a first-hand account of last summer's DC-X test—an event that obviously should mark the beginning of an important new road to the future, but whose chances of doing so look seriously clouded. We'll round out the issue with a smorgasbord of fiction by such writers as Grey Rollins, Bud Sparhawk, and Jerry Oltion, and an unusual and provocative guest editorial by G. David Nordley.

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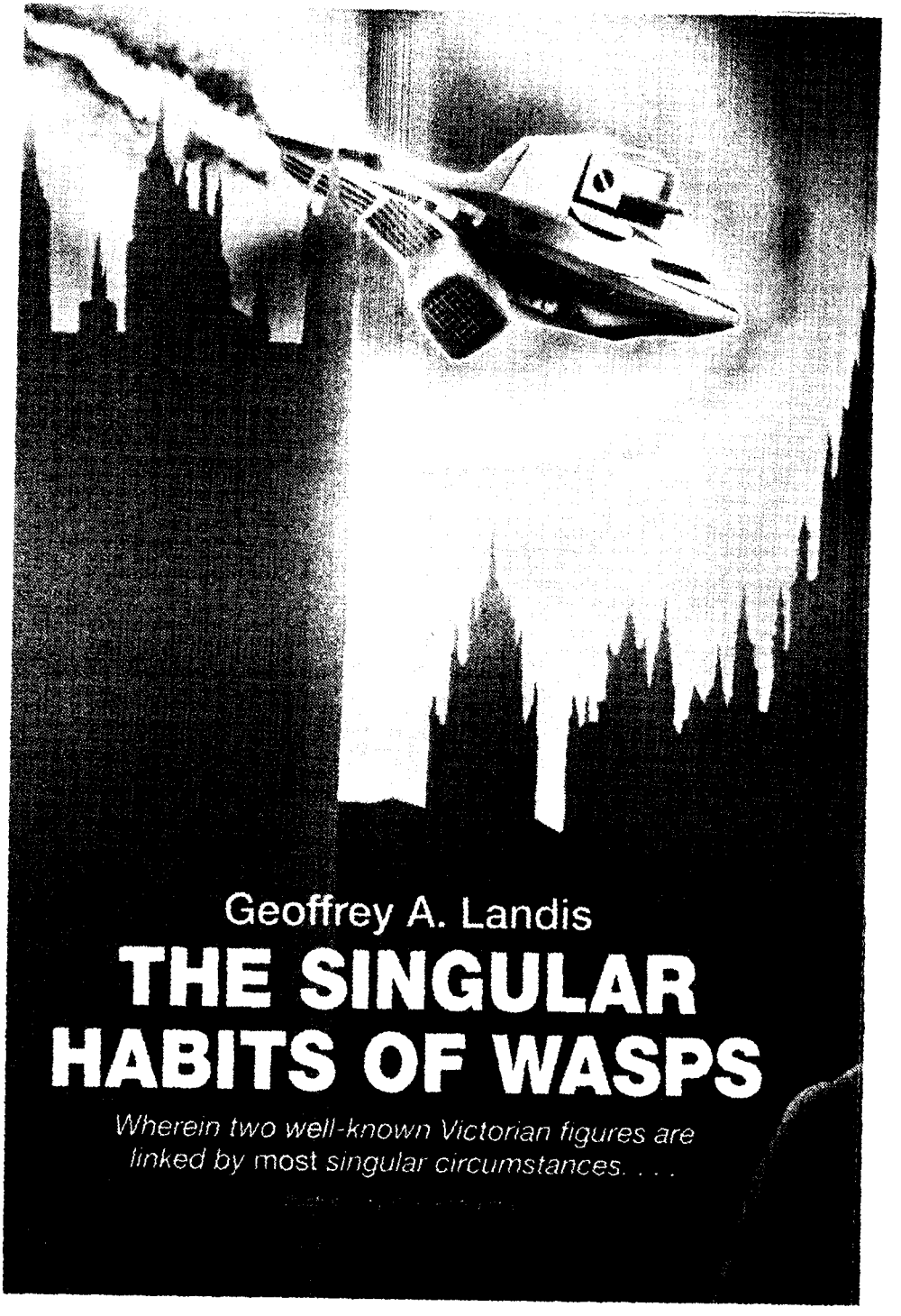

Geoffrey A. Landis

THE SINGULAR HABITS OF WASPS

Wherein two well-known Victorian figures are linked by most singular circumstances. . . .

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Of the many adventures in which I have participated with my friend Mr. Sherlock Holmes, none has been more singularly horrifying than the case of the Whitechapel killings, nor ever had I previously had cause to doubt the sanity of my friend. I need but close my eyes to see again the horror of that night; the awful sight of my friend, his arms red to the elbow, his knife still dripping gore, and to recall in every detail the gruesome horrors that followed.

The tale of this adventure is far too awful to allow any hint of the true course of the affair to be known. Although I dare never let this account be read by others, I have often noticed, in chronicling the adventures of my friend, that in the process of putting pen to paper a great relief occurs. A catharsis, as we call it in the medical profession. And so I hope that by putting on paper the events of those weeks, I may ease my soul from its dread fascination with the horrid events of that night. I will write this and then secret the account away with orders that it be burned upon my death.

Genius is, as I have often remarked, closely akin to madness, so closely that at times it is hard to distinguish the one from the other, and the greatest geniuses are also often quite insane. I had for a long time known that my friend was subject to sporadic fits of blackest depression, from which he could become aroused in an instant into bursts of manic energy, in a manner not unlike the cyclic moodswings of a madman. But the limits to his sanity I never probed.

The case began in the late springtime of 1888. All who were in London at that time will recall the perplexing afternoon of the double cannonade. Holmes and I were enjoying a cigar after lunch in our sitting room at 221 B Baker Street when the hollow report of a double firing of cannon rang out from the cloudless sky, rattling the windows and causing Mrs. Hudson's china to dance on its shelves. I rushed to the window. Holmes was in the midst of one of those profound fits of melancholia to which he is so prone, and did not rise from his chair, but did bestir himself so much as to ask what I saw. Aside from other, equally perplexed folk opening their windows to look in all directions up and down the street, I saw nothing out of the ordinary, and such I reported to him.

"Most unusual," Holmes remarked. He was still slumped almost bonelessly in his chair, but I believed I detected a bit of interest in his eye. "We shall hear more about this, I would venture to guess."

And indeed, all of London seemed to have heard the strange reports, without any source to be found, and the subject could not be avoided all that day or the next. Each newspaper ventured an opinion, and even strangers on the street talked of little else. As to conclusion, there was none, nor was the strange sound repeated. In another day the usual gossip, scandals and crimes of the city had crowded the marvel out of the papers, and the case was forgotten.

But it had, at least, the effect of breaking my friend out of his melan-

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cholia, even so far as to cause him to pay a rare visit to his brother at the Diogenes Club. Mycroft was high in the Queen's service, and there were few secrets of the Empire to which Mycroft was not privy. Holmes did not confide in me as to what result came of his inquiries of Mycroft, but he spent the remainder of the evening pacing and smoking, contemplating some mystery.

In the morning we had callers, and the mystery of the cannonade was temporarily set aside. They were two men in simple but neat clothes, both very diffident and hesitant of speech.

"I see that you have come from the south of Surrey," Holmes said calmly. "A farm near Godalming, perhaps?"

"Indeed we have, sir, from Covingham, which is a bit south of Godalming," said the elder of the visitors, "though how you could know, I'll never guess in all my born days, seeing as how I've never had the pleasure of meeting you before in my life, nor Baxter here neither."

I knew that Holmes, with his encyclopaedic knowledge, would have placed them precisely from their accents and clothing, although this elementary feat of deduction seemed to quite astound our visitors.

"And this is the first visit to London for either of you," said Holmes. "Why have you come this distance from your farm to see me?"

The two men looked at each other in astonishment. "Why, right you are again, sir! Never been to London town, nor Baxter."

"Come, come; to the point. You have traveled this distance to see me upon some matter of urgency."

"Yes, sir. It's the matter of young Gregory. A farm hand he was, sir, a strapping lad, over six feet and still lacking 'is full height. A-haying he was. A tragic accident t'was, sir, tragic."

Holmes of course noticed the use of the past tense, and his eyes brightened. "An accident, you say? Not murder?"

"Yes."

Holmes was puzzled. "Then, pray, why have you come to me?"

" 'Is body, sir. We've come about 'is body."

"What about it?"

"Why, it's gone, sir. Right vanished away."

"Ah." Holmes leaned forward in his chair, his eyes gleaming with sudden interest. "Pray, tell me all about it, and spare none of the details."

The story they told was long and involved many diversions into details of life as a hired hand at Sherringford Farm, the narration so roundabout that even Holmes's patience was tried, but the essence of the story was simple. Baxter and young Gregory had been working in the fields when Gregory had been impaled by the blade of the mechanical haying engine. "And cursed be the day that the master ever decided to buy such an infernal device," added the older man, who was the uncle and only relation of the poor Gregory. Disentangled from the machine, the young farmhand had been still alive, but very clearly dying. His abdomen had been ripped open and his viscera exposed. Baxter had laid the dying man

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in the shade of a hayrick, and gone to fetch help. Help had taken two hours to arrive, and when they had come, they had found the puddle of congealing blood, but no sign of Gregory. They had searched all about, but the corpse was nowhere to be found, nor was there any sign of how he had been carried away. There was no chance, Baxter insisted, that Gregory could have walked even a small distance on his own. "Not unless he dragged 'is guts after him. I've seen dying men, guv, and men what 'ave been mere wounded, and young Gregory was for it."

"This case may have some elements of interest in it," said Holmes. "Pray, leave me to cogitate on the matter tonight. Watson, hand me the train schedule, would you? Thank you. Ah, it is as I thought. There is a 9 A.M. train from Waterloo." He turned to the two men. "If you would be so good as to meet me on the morrow at the platform?"

"Aye, sir, that we could."

"Then it is settled. Watson, I do believe you have a prior engagement?"

That I did, as I was making plans for my upcoming marriage, and had already made firm commitment in the morning to inspect a practice in the Paddington district with a view toward purchasing it. Much as I have enjoyed accompanying my friend on his adventures, this was one which I would have to forego.

Holmes returned late from Surrey, and I did not see him until breakfast the next morning. As often he was when on a case, he was rather uncommunicative, and my attempts to probe the matter were met with monosyllables, except at the very last. "Most unusual," he said, as if to himself. "Most singular indeed."

"What?" I asked, eager to listen now that it appeared that Holmes was ready to break his silence.

"The tracks, Watson," he said. "The tracks. Not man, nor beast, but definitely tracks." He looked at his pocket-watch. "Well, I must be off. Time enough for cogitation when I have more facts."

"But where are you going?"

Holmes laughed. "My dear Watson, I have in my time amassed a bit of knowledge of various matters which would be considered most *recherché* to laymen. But I fear that, on occasion, even I must consult with an expert."

"Then whom?"

"Why, I go to see Professor Huxley," he answered, and was out the door before I could ask what query he might have for the eminent biologist.

He was absent from Baker Street all afternoon. When he returned after suppertime I was anxious to ask how his interview with the esteemed professor had gone.

"Ah, Watson, even I make my occasional mistake. I should have telegraphed first. As it was, Professor Huxley had just left London, and is not to return for a week." He took out his pipe, inspected it for a moment, then set it aside and rang for Mrs. Hudson to bring in some supper. "But in this case, my journey was not in vain. I had a most delightful discussion with the professor's protégé, a

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Mr. Wells by name. A Cockney lad, son of a shopkeeper and no more than twenty-two, unless I miss my guess, but a most remarkable man nonetheless. Interested in a wide variety of fields, and I venture to say that in whatever field he chooses, he will outshine even his esteemed teacher. Quite an interesting conversation we had, and a most useful one."

"But what was it that you discussed?" I asked.

Holmes set aside the cold beef that Mrs. Hudson had brought, leaned back in his chair, and shut his eyes. For a while I thought that he had gone to sleep without hearing my question. At last he spoke. "Why, we discussed the planet Mars," he said, without opening eyes. "And the singular habits of wasps."

It seemed that his researches, whatever they were, led to no distinct conclusion, for when I asked him about the case the next day, he gave no response. That day he stayed in his chambers, and through the closed door I heard only the intermittent voice of his violin speaking in its melancholy, unfathomable tongue.

I have perhaps mentioned before that my friend would habitually have more than one case on which he worked at any one time. It appeared that over the next few evenings he was about on another one, for I found him dressing to go out at a late hour.

"Another case, Holmes?" I asked.

"As you can see, Watson," he replied. He indicated his less-than-respectable outfit and the threadbare workman's jacket he was pulling on over it. "Duty calls at all hours. I shan't be more than a few hours, I expect."

"I am ready to assist."

"Not in this one, my dear friend. You may stay home tonight."

"Is there danger?"

"Danger?" He seemed surprised, as if the thought hadn't occurred to him. "Danger? Oh, perhaps a slight bit."

"You know that I would not hesitate—"

"My dear doctor," he said, and smiled. "Let me assure you that I am not worried on that score. No, it is that I go to the East End. . . ."

The East End of London was no place for gentlemen, with slaughterhouses and tenements of the lowest order; a place for drunkards, sailors, Chinese and Indian laborers, and ruffians of all sorts. Nevertheless I was quite willing to brave much worse, if necessary, for the sake of Holmes. "Is that all?" I said. "Holmes, I do believe you underestimate me!"

"Ah, Watson. . . ." He seemed to reflect for a moment. "No, it would not do. You are soon to be married, and have your wife-to-be to think of." He raised a hand to forestall my imminent objection. "No, not the danger, my friend. Don't worry for me on that score. I have my resources. It is . . . how to put it delicately? I expect that I shall meet people in places where a gentleman soon to be married would best not be seen."

"Holmes!"

"Business, my dear Watson. Business." And with that, he left.

His business there did not seem to

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be concluded that evening or the next. By the end of August he was visiting the East End once or twice a week. I had already become used to his odd hours and strange habits, and soon thought nothing of it. But he was so habitual about it, and so secretive, that it soon caused me to wonder whether perhaps he might be calling upon a woman. I could think of nothing that seemed less like Holmes, for in all my time with him he had never expressed a trace of romantic interest in the fairer sex. And yet, from my own medical experience, I knew that even the most steadfast of men must experience those urges common to our gender, however much he might profess to disdain romance.

Romance? Though I myself never frequented such places, as an Army man I knew quite as well as Holmes what sort of women dwelt in Whitechapel, and what profession they practiced. Indeed, he had admitted as much when he had warned me away "because I was to be married." But then, a woman of such type could well appeal to Holmes. There would be nothing of romance involved. It would be merely a business proposition for her, and a release of pressure for him. A dozen times I resolved to warn him of the dangers—the danger of disease, if nothing else—in patronizing women of that sort, and so many times my nerve failed and I said nothing.

And, if it were not what I feared, what case could it be that would take him into Whitechapel with such frequency?

* * *

One evening shortly after Holmes had left, a message boy delivered a small package addressed to him. The address proclaimed it to be from a John B. Coores and Sons, but gave no clue to its contents. This name seemed to me familiar, but, struggle as I might, I could not recall where I might have seen it before. I left it in the sitting room for Holmes, and the next morning saw that he had taken it. He made no mention of the package or of what it contained, however, and my curiosity over it remained unslaked.

But another event soon removed that curiosity from my mind. The newspaper that morning carried a report of a brutal murder on Buck's Row in Whitechapel. The body of an unidentified woman had been found on the street, and, what was even more grotesque, after her death her body had been brutally sliced open. I read the paper to Holmes as he sat drinking coffee in the morning. As far as I could tell, he had not slept the previous night, although he seemed little the worse for it. He made no comment on the article. It occurred to me that for all its gruesome features, this was the sort of commonplace murder he would have no interest in, since it seemed quite lacking in the singular points that so interested him. I made a comment to him to that effect.

"Not so, Watson," he said, without looking up. "I am quite interested to hear what the press has to say about the Nichols tragedy."

This comment startled me consid-

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erably, since the paper had given no name to the victim. I suddenly remembered that East London was exactly where Holmes was going for all these evenings, perhaps to the very place the murder had occurred.

"My God, Holmes! Did you know her?"

At this he looked up, and gave me a long piercing stare. After a long while he looked away and gave a short laugh. "I do have my secrets, Watson. Pray, inquire no further."

But to me his laughter sounded forced.

It was a week before I saw Holmes prepare for another of his nocturnal sojourns. After napping all afternoon, Holmes was again dressing in faded and tattered clothing. This time I did not ask, but silently dressed to follow.

When he put on his ear-flapped traveling cap, I was ready as well. I quietly walked to his side, clutching my old service revolver in the pocket of my coat. He looked at me with an expression of utmost horror and put up a hand. "My God, Watson! If you value your life and your honour, don't follow me!"

"Just tell me this, then," I said. "Are you doing something . . . dishonourable?"

"I am doing what I must." And he was out the door and gone in the time it took me to realize that he had in no way answered my question.

As I prepared for bed that night, wondering where Holmes had gone and what he was doing there, it suddenly occurred me where I had seen the name John B. Coores and Sons before. I crossed the room, thrust open the cabinet where I kept medical supplies, and drew out a small wooden box. There it was. I had looked at the name a thousand times without really seeing it, neatly lettered on the side of the box: John B. Coores and Sons, Fine Surgical Instruments. But what could Holmes want with surgical tools?

And in the next evening's paper, I saw with horror that there had been another murder. The Whitechapel killer had struck again, and once more he had not contented himself with merely killing the woman. Using a surgical knife and a knowledge of anatomy, he had dissected the body and removed several organs.

That Sunday I took my beloved Mary to the theatre. My thoughts were dark, but I endeavoured to allow none of my turmoil to be communicated to her, hoping instead that her sweet presence might distract me from my dire speculations. Events plotted against me, however, for playing at the Lyceum was a most disturbing play, *The Strange Case of Dr. Jekyll and Mr. Hyde*. I watched the play with my mind awhirl, scarcely noticing the presence of my beloved at my side.

After the play I pleaded sudden ill health and fled home. Seeing my ashen face, Mary heartily agreed that I should go home to rest, and it was all I could do to dissuade her from accompanying me back to serve as a nurse.

The play had been presented as

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fiction, but it had hit a note of purest truth. That a single man could have two personalities! Stevenson had been circumspect about naming the drug that would so polarize a man's psyche as to split his being into two parts, but with my medical knowledge I could easily fill in the name; and it was a drug I had intimate knowledge of. Yes. A man could suppress his animal instincts, could make himself into a pure reasoning machine, but the low urges would not wither away, oh no. They would still be there, lurking inside, waiting a chance to break loose.

I had thought that either Holmes was stalking the Whitechapel killer, or else that Holmes was the killer. Now I suddenly realized that there was yet another alternative: Holmes the detective could be stalking the Whitechapel killer, completely unaware that he himself was the very criminal he sought.

It was a week before he went out again. The following day I scanned the newspapers in an agony of suspense, but there was no murder reported. Perhaps I was overwrought and imagining things? But Holmes seemed haunted by something, or perhaps hunted. There was something on his mind. When I invited him to confide in me, he looked at me for a long time and then slowly shook his head. "I dare not, Watson." He was silent for a while, and then said, "Watson, if I should suddenly die—"

At this I could take no more. "My God, Holmes, what is it? Surely you can tell me something!"

"This is important, Watson. If I should die . . . burn my corpse. Promise me that."

"Holmes!"

He gripped my shoulder and looked intently into my eye. "Promise me, on your honour."

"I promise."

"On your honour, Watson!"

"On my honour, I promise."

He suddenly relaxed, almost collapsing into his chair. "Thank you."

That night again he went out, and again the next. His face was drawn, as if he were desperately seeking something he had been unable to find on the previous night. Both evenings he seemed on the brink of saying something to me, only to think better of it at the last moment, and vanish without a word into the London night.

The next evening's papers told of not one, but two murders in the East end. The Whitechapel killer—now called 'Jack the Ripper' by all the papers—had worked double duty. And this time a witness had given a description of the suspected killer: a tall man in a dark cutaway overcoat, wearing a felt deerstalker hat.

I confronted Holmes with the papers and my suspicions. I had hoped, more than I hope for paradise, that he would dismiss my deductions with his soft, mocking laugh, and show me some utterly commonplace alternative explanation of the facts. My hopes were in vain. He listened to my words with his eyes nearly shut, his briar pipe clenched unlit between his teeth. Finally my words ground to a stop against his stony silence. "My

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God, Holmes, tell me I'm wrong! Tell me that you had nothing to do with those murders, I beg of you.'"

"I can say nothing, my friend."

"Then give me some reason, some shred of sanity."

He was silent. Finally he said, "Do you intend to go to the police with your suspicions?"

"Do you want me to?" I asked him.

"No." His eyes closed for a moment, and then he continued, "But it doesn't matter. They would not believe you in any case." His voice was weary, but calm. His manner did not seem that of a madman, but I know that madmen can be fiendishly clever in concealing their madness from those about them. "Are you aware of how many letters and telegrams have flooded Scotland Yard in these last few weeks? The Yard is a madhouse, Watson. Landladies and madmen, people claiming to have seen the Ripper, to know the Ripper, to *be* the Ripper. They receive a thousand letters a week, Watson. Your voice would be lost in the madness." He shook his head. "They have no idea, Watson. They cannot begin to comprehend. The Whitechapel horror, they call it. If the true horror of it were known, they would flee the city; they would scream and run in terror."

Despite everything, I should have gone to the police, or at least have confided my suspicions to someone else and asked for counsel. But I knew of no one in whom to confide such an awful suspicion, least of all my Mary, who trusted Holmes nearly as a god and would hear no ill of him. And, despite all, in my heart of hearts I still believed that I must have read the evidence awry, that Holmes could not truly be a culprit of such infamy.

The next day, Holmes made no reference to our conversation. It seemed so strange that I thought to wonder if it had actually occurred, or if I had dreamed the entire thing. I determined that, without giving any outward sign of it to Holmes, I should keep my eyes sharp on him like a hawk. The next time that I saw him making preparations to leave on a nocturnal sojourn, I would follow him, whether he wanted it or no.

Holmes made several trips to Whitechapel during the daytime, and gave no objection when I asked to accompany him. It was no place for decent humans to live. The streets were littered with the filth of horses, pigs, chickens, and humans, and the air clamorous with the clatter of delivery wagons and trains, the carousal of children and drunkards, and the cackling of chickens and bawling of pigs which lived side-by-side with people in the basements and dosshouses. Above us, hanging from every window, ragged wash turned dingy grey as it dried in pestilence-ridden air.

During these trips he did little other than inspect the streets and look over the blank, white washed brick walls of warehouses and blind alleys. On occasion he would stop for a brief chat over inconsequential matters with a charwoman or a policeman he might meet walking the narrow alleyways. Contrary to his nature, he made no attempt to visit the scenes of the crimes. To me this last

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fact was the most damning to my suspicions. Unless he were involved in some way, surely there would have been no possibility that anything could have kept him away.

But it was all of October and a week into November before he again left on one of his evening peregrinations. But for an accident of chance, I would have missed it entirely. I had laid out several traps for him, so as to awaken me if he tried to leave in the night, and sat wakeful in the evenings until long after I had heard him retire. One night in early November, after retiring without incident, I was unexpectedly awakened in the middle of the night by some noise. The night was foggy, and through my window I could hear only the most muffled sounds of the street, as if from a tremendous distance, the clopping of a lone set of hooves and the call of a man hailing a hansom. For some reason I was unable to get back to sleep, and so I put on my dressing-gown and descended to the sitting room to take a finger of whiskey.

Holmes was gone. His door was ajar, but the bed was empty.

I was determined to know the truth, whatever it might be, and thus in one way or another to bring this adventure to an end. I dressed hurriedly, thrust my service revolver into a pocket of my overcoat, and ran out into the night. At that hour, well after midnight, I had only the most remote hope of finding a cab anywhere near our Baker Street diggings. Sometime during the day Holmes must have surreptitiously arranged for the cab to meet him that night. As I had made no such arrangements, he had quite the head start on me. It was the better part of an hour before I made my way past Aldgate pump and entered the East End slums.

I had suspected that in the wake of the killings the streets of Whitechapel would be deserted, the public houses closed and the citizens suspicious of any strangers. But even at this late hour the streets were far from deserted. It was a busy, populous area. Wandering aimlessly on the streets, I found many open pubs, most all crowded with unemployed workmen and idle women of dubious repute. Everywhere I walked I found that I was not more than a hundred yards from a citizen's patrol or a watchful, armed constable—several of whom watched me with an intent, suspicious gaze. Even the women on the street corners, wearing shawls and bonnets to ward against the wet November night, stood in groups of two and three.

Holmes I could find nowhere, and it occurred to me belatedly that if he were in one of his disguises, he could be any of the people about me—one of the unemployed mechanics gambling in the front room of the Boar and Bristle, the aged clergyman hustling down Commercial Street toward some unknown destination, the sailor chatting up the serving girls at the King's Arms. Any of these could be Holmes.

Any of these could be the Ripper.

All around me there were women, in the pubs, in the doorways, walking the streets; pathetic women dressed in cheap finery, with tired smiles and

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the flash of a stockinged ankle for any passers-by wearing pants—"you lonely, love?"—or with saucy greetings and friendly abuse for the other women.

I realized that the size of Whitechapel that showed on the map was deceptive. In the fog and the darkness the streets were far more narrow, the shops smaller, and the whole larger and more cluttered that I recalled from the daytime. Even if there were a hundred constables patrolling the streets it would not be enough. The blind alleys, the sparse gas lights, and the drifting banks of fog made the streets a maze in which the Ripper might kill with impunity within a few yards of a hundred or more people.

Twice I thought I caught a glimpse of Holmes, but, when I ran after him, found that I had been deceived. Every drunkard sleeping in a doorway seemed to be a fresh corpse, every anonymous stain on the cobblestones looked like blood, every wandering alley-cat seemed the shadow of a lurking killer. Several times I contemplated giving up my hopeless errand and going home, managing to keep on only by promising myself that I would stay on for just one hour more.

In the dark hour before sunrise I found him.

I had come into a pub to warm myself for awhile. The barman was surly and uncommunicative, evincing a clear suspicion of my motives that, while perhaps well enough justified by recent events, nevertheless made the atmosphere inside scarcely less chill than that of the night outside. The beer was cheap and thoroughly watered. At first a few of the women had come by to pass time with me, but I found them pathetic rather than alluring, and after a bit they left me in solitude.

After an hour or so of this, I went out into the night air to clear my head of the smoke and stink. A light rain had cleared most of the fog away. I walked at random down the streets and up alleyways, paying no attention to where I headed.

After walking for some time, I was disoriented, and stopped to get my bearings. I had no idea where I was. I turned a corner and looked down into an unmarked court, hoping to descry a street sign, but had no luck. In the darkness I saw something ahead of me; a pair of legs protruding from the arch of an entranceway. I walked forward, my blood chill. It was the body of a woman laid on the cobblestones, skirts awry, half concealed in a doorway. I had seen a dozen such in the last few hours, drunkards too poor to afford a bed, but in the instant of vision a dread presentiment came to me that this one was not merely drunk and asleep. The darkness beneath her body looked darker and more liquid than any mere shadow. I knelt down, and touched her wrist to take a pulse.

Her eyes flew open. It took a moment for her to focus on me. Suddenly she shrieked and stumbled to her feet. "Lord have mercy! The Ripper!" she said in a hoarse whisper. She tripped over her petticoats in a clumsy effort to stand and run at the same time, and fell to her knees.

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"My pardons, Miss," I said. "Are you all right?" Without thinking, I reached down a hand to help her up.

"Murder!" she shrieked, scrambling away on all fours like an animal. "Oh! Murder!"

"Madam, please!" I backed away into the alley behind me. It was evident that nothing I could do would calm her. She continued to yell as she clattered away, darting frightened glances back at me over her shoulder. The courtyard I was in was dark and silent, but I was afraid that her cries would wake others. I stepped backwards into a doorway, and suddenly found the door behind me yield to the pressure. It had not been latched. Off balance, I half-fell backwards into the room.

The room was thick with the cloying, coppery odor of blood. The hand I had put down to steady myself came up slick with it. By the wan light of the fire in the grate across the room I could see the bed, and the dark, twisted shape on it, and I had no need to look more closely to know what it was.

The body of the woman on the bed had been so badly mutilated that it was hardly recognizable as human. Blood was everywhere. In a daze I reached out a hand to feel for a pulse.

Her hand was already cool.

Her skirt had been removed, her petticoats cut away, and her body neatly opened from pubes to sternum by some expert dissector.

I was too late. I gave a low moan. Somewhere before me I heard a low, steady dripping. I looked up, and stared into the pale face of Sherlock Holmes.

His eyes were weary, but empty of any trace of the horror that I felt. He was standing in the room behind the body, and as my eyes adjusted to the shadows I saw that he held a dissecting knife. His arms were red to the elbows, and gore dripped in a monotonous rhythm from the knife onto the stone floor. At his feet was a worn leather shopkeeper's satchel, half open.

"There is nothing you can do for her, Doctor," said Holmes, and the calm, even voice in which he said this pierced me with chill. It was not the Holmes I knew. I was not sure if he even recognized me. He bent down to snap the satchel shut before I had more than a brief glimpse of the bloody meat within it, then wiped the scalpel on the canvas apron he wore, put it carefully back into the small wooden case, and dropped it into an outside pocket of the bag.

He tugged at his left elbow, and only then did I realize that he wore full-length gloves. He was well prepared for this venture, I thought, my mind in a state of shock. He removed the gloves, tossed them into the fire grate, and pushed at them with a poker. They smoldered for a moment and then caught fire, with the heavy charnel stink of burning blood. Beneath his apron he wore clothes such as any tradesman might wear.

"My God, Holmes!" I stuttered. "Did you kill her?"

He sighed deeply. "I don't know. Time is short. Please follow me, Watson."

At least he recognized me. That

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was a good sign. I followed him out of long habit, too numb to do anything else. He closed and locked the door behind him and put the key into his pocket. He led me through a small gate, down a cluttered alley, then quickly through two narrow passageways and into a courtyard behind the slaughterhouses. The key and the apron he discarded there. I saw he had a cab waiting, the horse tethered to an unlit lamppost. There was no cabman in sight. "Take me home, Watson," he said. "You should not have come. But, since you are nevertheless here, I confess myself glad of the chance to unburden myself of the awful things that I have seen and done. Take me home, and I shall conceal nothing from you."

I drove and Holmes sat in back, meditating or sleeping, I could not tell which. We passed three constables, but I did not stop. He bade me halt at a certain mews not far from Baker Street. "The cabman will be here in half an hour," he said, as he tended expertly to the horse. "He has been paid in advance, and we need not wait."

"I believe you must think me most utterly mad, Watson," said Holmes, after he had exchanged his rough clothes for a dressing-gown, meticulously cleaned himself of dirt and splattered blood, fetched the Persian slipper in which he kept his tobacco, and settled back in his chair. "You have not loosened your grip on that service revolver of yours for the last hour. Your fingers must be cramped by now, you have been clutching it so strongly—ah," he said, as I opened my mouth to deny this, "no use in your protesting your innocence. Your hand has not strayed from the pocket of your robe for an instant, and the distinctive weight of your pistol is quite clearly evident in it. I may be mad, my dear Watson," he said with a smile, "but I am not blind."

This was the Holmes I knew, and I relaxed. I knew I had nothing to fear from him.

His hand hesitated over his rack of pipes, selecting his clay-stemmed pipe, and filled it with shag. "Indeed, Watson, at times during these last months I would not have disputed it with you myself. It would have been a relief to know myself mad, and that all I have seen and conjectured to be merely the delusions of a maniac."

He teased a coal out of the grate and lit his pipe with it. "To begin, then, with the missing corpse." He puffed the pipe until its glow matched that of the fire behind him. "Or, perhaps better," he said, "I should begin with the London cannonade." He raised a finger at my imminent objection. "I have promised to tell all, Watson, and I shall. Pray let me go about it in my own way.

"My brother Mycroft," he continued, "made a most interesting comment when I discussed the matter of the cannonade with him. He mentioned that when a highly-powered cannon is fired, an observer at the front lines ahead of the artillery and distant from the firing will hear a very distinct report at the instant the shell passes. This is the crack of displaced air. This report comes considerably

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in advance of the actual sound of the cannon firing. If our ears were but sensitive enough to hear it, he informed me, this report would be heard as two distinct waves, one of the air compressed by the shell, and another of the air rushing inward to fill the vacuum left behind it. An aeroship which traversed faster than the velocity of sound would produce a like crack, and, if it were large enough, the two waves would be heard as distinct reports.

"My brother discussed this only as an abstract but interesting fact, but I know him well enough to understand the meaning behind his words.

"Taking this as a provisional theory, then, and judging by the fact that observers noted the timing between the two reports was briefer in the north than in the south of London, we find that the hypothetical aeroship must have been slowing down as it traveled south."

"But Holmes," I said, my mind in total consternation, "an aeroship? And one which moves faster than an artillery shell? No nation on God's Earth could make such a thing, not to mention the impossibility of keeping it a secret."

"Precisely," said Holmes. He took another puff from his pipe. "This brings us to the case of the missing corpse. I had been looking for a reason to investigate south of London, and the case presented by the two farm-hands was quite fortuitous in that respect.

"You know my method, Watson. It was unfortunate that the men in the original searching party had in many places quite trampled the tracks that I needed, but in the few places where they could be clearly distinguished, the tracks told a most puzzling story. Some animal or animals had circled the hayrick, leaving tracks like nothing I had ever seen. I could make nothing of the footprints, save that one side was dragging slightly, as if one of the animals were limping. From the depth of the impressions they must have been the size of small dogs. What was most peculiar about the set of tracks was that the animals seemed to march in precision step. The strange thought occurred to me then, that the tracks of a single animal with eight or more legs might leave exactly such impressions. The steps led to the place where the dying man had lain, and circled about. Of outgoing tracks, there were only those of the men who had tended him and those of the searchers.

"I attempted to follow the tracks backward, but could follow back no more than a mile to where they emerged from a sheep meadow and were obliterated by the hoofprints of innumerable sheep. All that I could determine from this was that the animals had been severely panicked at some time in the last few days, running over and around each other and back and forth across the field.

"I turned my attention back to the impressions made by the dying man, and the tracks of the men away from the spot. I inspected the tracks of the unusual animal further. They were extremely strange, and in some ways rather insectlike. The animal's tracks overlaid two of the other tracks,

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which I knew to be those of the men who had summoned me. Over these tracks, however, were those of a third man.

"I quickly determined these tracks to be those of the dying man himself. After the two men had left, he had risen up and walked away, apparently carrying the strange animal with him."

"My God, Holmes," I interjected. The revolver lay forgotten in my pocket. "You can't be serious. Are you suggesting some sort of voodoo?"

Holmes smiled. "No, Watson, I am afraid that it was something far more serious than mere superstition.

"The man had crawled on all fours for a few feet, then stood up and walked in a staggering, unbalanced stride. After a few unsteady moments, however, he found his feet and began to walk quickly and purposefully in a straight line. Soon he came to a hard-packed road, where his traces were obliterated by the traffic and I could track his movements no further. His aim, though was quite clearly toward London, and this I took to be his goal."

Listening to his narrative I had completely forgotten the events of the previous night, the slain street-walkers, and my suspicion of Holmes.

"At this point," Holmes continued, "I knew that I needed to consult an expert. Mr. Wells, of whom I spoke earlier, was that expert, and I could not have asked for a better source. We discussed the possibility of life on other worlds. Mr. Wells offered the opinion that, since there are millions upon millions of suns very much like our own Sun in the sky, that certainly there must be other intelligences, and other civilisations, some of which must be as far beyond ours as our English civilisation is beyond that of the African savage."

"Then you take this strange aeroship to be a vehicle from another world?" I asked. While I had heard such ideas discussed in popular lectures on astronomy, I had, heretofore, always dismissed these as purest fancy.

"A provisional hypothesis, to be confirmed or forgotten as further data became available. I went on to ask Mr. Wells whether such citizens of other worlds might be human in shape and thought. At this suggestion he was most frankly contemptuous. Such beings would have no more reason to be shaped in our form, he said, than we in that of an octopus or an ant. Likewise they might take no more notice of our civilisation and our morality than we take of the endeavors and ethics of an ant hill.

"This I had already surmised. I turned the talk to biology, and without tipping my hand, managed to steer the conversation to the unusual life-cycles of other species. One in particular he mentioned struck my attention, the life-cycle of the ichneumon, or solitary wasp."

"Really, Holmes. Wasps? I do believe that you are toying with me."

"I wish that I were, my dear doctor. Pray listen; all of this is germane to the subject at hand. The ichneumon wasp has a rather gruesome life-cycle. When the female wasp is ready to lay eggs, it finds and stings a cicada, often

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one much larger than itself, and then deposits its egg inside the body of the paralyzed but still living insect. This insect then serves as sustenance for the hatching larva, which forms its home within the living insect, having the instinct to avoid eating the essential organs until the very last, when it is ready to exit into the world to lay eggs of its own.

"This was enough for me to frame my provisional hypothesis. I believed that some strange being from the aeroship had not merely met the fatally injured man, but crawled inside his body and taken control of his gross physical function.

"I was struck by one fact. Of all the people that this . . . alien . . . might have met, it was a dying man who he—it—actually chose. Clearly, then, the . . . thing . . . believed itself unable to subdue an uninjured person."

"I must confess, Holmes, if I were asked to prove your sanity, this story would hardly bolster your case."

"Ah, Watson, always the practical man. Permit me." He got out of the leather chair, crossed the room to where he had put down the leather satchel, and laid it on the table in front of me.

I sat paralyzed. "I dare not, Holmes."

"Your courage has never failed you before, my friend."

With a shudder I touched the satchel, and then, steeling myself, opened it. Inside was some object covered in streaks of gore. I didn't want to look, but I knew that I must.

The two eggs inside were of a translucent purplish white, large as a moderate-sized mango, and slick with a film of blood. Within each one a monstrous coiled shape could be discerned. No Earthly animal ever laid such an egg, of this I was sure. More horrible than the eggs was the other thing. I shuddered and looked away. It was something like a giant prawn, and something like some jungle millipede, with dozens of long barbed feelers and multiply-jointed appendages bristling with hooks and spines. Its head, or what passed for a head, had been nearly severed with a knife, and the wound exuded a transparent fluid rather like whale-oil, with a sharp and unpleasant odor similar to kerosene. Instead of a mouth, it had a sucking orifice rimmed with myriad tiny hooked teeth.

"This is what I removed from her body," Holmes said.

I looked up at him. "My God," I whispered. "And she was not dead?"

"You asked that question before. It is a question of definitions, Watson. All that was left alive in her body was the thing that you see. By removing it, did I kill her?"

I shuddered again, and slammed the satchel shut with my eyes averted. "No." I stood for a moment, trying to regain my composure. "But why Whitechapel?"

"What you saw was a juvenile," said Holmes. "The adult would be much larger. I would not know if it is intelligent, or what we call intelligent, but it is at least very clever. Why Whitechapel? Think, Watson. It had eggs and juveniles it must deposit into a living body. But how is it to approach a complete stranger, em-

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brace him—or her—closely enough to? Ah, you see the picture. It was the perfect place for the thing, Watson; the only place where it could do what it needed.

"I studied the East End in minute detail, tracing the path of the mysterious stranger. Again and again I was too late, sometimes only by minutes. I removed the juveniles from the corpses out of necessity. I say corpses, Watson, for although they still walked upright they were already dead. Had I not killed them, they would have gone to cover until they were mature. I could find the one, I knew, only by concentrating on the one trail. Even then it would be a near thing. Two of them, and I were lost."

"Why didn't you go to the police?"

"And tell them what? To start a manhunt for a thing they can only find by ripping open bodies?"

"But the letters? The ones from 'Jack the Ripper'—did you write these?"

Holmes laughed. "Why should I need to?" he said. "Fakes, forgeries, and cranks, every one. Even I am continuously amazed at how many odd people there are in London. I daresay they came from newspapers hungry to manufacture news, or from pranksters eager at a chance to make fools of Scotland Yard."

"But, what do we do?"

"We, Watson?" Holmes raised an eyebrow.

"Surely you wouldn't think that, now that I know the danger, I would let you continue alone."

"Ah, my good Watson, I would be lost without you. Well, I am hot on its trail. It cannot elude me much longer. We must find it and kill it, Watson. Before it kills again."

By the next morning the whole episode seemed a nightmare, too fantastical to credit. I wondered how I could have believed it. And yet, I had seen it—or had I? Could I have deluded myself into seeing what Holmes had wanted me to see?

No. It was real. I could not afford to doubt my own sanity, and hence I must believe in Holmes's.

In the next few days Holmes went back to his daytime reconnaissance of the East End, mapping the way buildings abutted and how doorways aligned with alleys, like a general planning his campaign, stopping for conversation with workmen and constables alike.

On the third day, my business in town kept me late into the evening. At the end of it, it was almost certain that I had purchased a practice, and at a price which I could afford, but the sealing of the deal required an obligatory toast, and then there were more papers to be inspected and signed, so that all in all, it was well past ten in the evening when I returned to Baker Street.

Of Holmes there was only a note: "I have gone to see the matter to its conclusion. It is better that you are out of it, and I shall think no less of you if you stay. But if you must follow, then look for me near the blind court at Thrawl Street." I read it and swore. He seemed determined to leave me out of this adventure, no matter how dangerous it was for him alone. I

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snatched my greatcoat and hat from the hall stand, fetched my revolver out from the drawer where it resided, and went out into the night.

It was the night of the great carboniferous fog. The gas-lights were pale yellow glimmers that barely pierced the roiling brown stink. The cab I hailed almost ran me down before seeing me in the street in front of him.

The fog in Whitechapel was even thicker and yellower than that of Baker Street. The cab left me off in front of the Queen's Head pub, the cabbie warning me of the danger of the neighborhood. The blind court was one which was being resurfaced by the MacAdam method, in which the street was covered with liquid tar, and a layer of gravel rolled into the tar surface. The process results in a surface which is even and far easier to repair than cobblestone. I can see the day when all of London will have such smooth quiet streets.

Earlier Holmes had talked with some of the workmen as they rolled the gravel. Now they were long gone. The half-full cauldron of tar was still at the corner of the alley. Although the oil-pot which heated it to boiling had been removed, the cooling drum of tar still gave out quite a bit of heat.

Three unfortunate women had lit a small fire out of wood-scraps and huddled between the warm cauldron and their fire, with their hands toward the tiny fire and their backs against the cauldron for warmth. The glow of the fire gave a luminous orange cast to the surrounding fog. A tiny pile of additional wood scraps stood waiting to keep the fire going for the rest of the night.

Holmes was nowhere in sight.

The women spotted me looking at them, and whispered amongst themselves. One came up to me and attempted a smile. "Care to spend some money and buy a poor unfortunate a drink, dearie?" She tossed her head toward the end of the street where the pub was invisible in the fog, and at the same time flicked her skirt in such as way as to allow me a clear view of her bare ankle.

I averted my eyes. "I'm looking for a friend."

"I could be a friend, if you wanted me to."

"No. I don't need . . . that sort of comfort."

"Oh, sure you do, dearie." She giggled. "All men do. 'Sides, I h'aint even got money for me doss. Surely a fine gent like yourself has a shilling to spend on a poor lady down on 'er luck, hasn't he? Sure 'e does."

I looked at her more closely, and she preened for my inspection. She might have been a rather pretty woman, striking if not actually beautiful, if she had been given the chance. Instead I saw the lines on her face, the threadbare bonnet she wore, and the unmistakable signs of the early stages of consumption. Such a woman should be resting in bed, not out standing in the chill of a night such as this. I was about to speak to her, to invite her into the public house for the drink she requested, for no other reason than to get her out of the chill and away, perhaps, from the monster that stalked the fog-shrouded night. I

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could wait for Holmes as well in the pub as in the street.

As I was about to speak, I heard a man approach from the blind end of the court, although I had seen no one there previously. I started to call out, thinking it must be Holmes, but then saw that, while the man was quite as tall as Holmes, he was much bulkier, with a considerable paunch and ill-fitting clothes. As he passed, another of the women smiled at him and called out a greeting. He nodded at her. As she put out her arm for him to take, he dropped his hand to the buttons of his pants. I looked away in disgust, and as I did so the woman who had spoken to me slipped her arm around mine.

I had lost track of the third woman, and was as surprised as the others when her voice rang out from behind. "Stop, fiend!"

The voice was calm and authoritative. I looked up. The woman was holding a revolver—Holmes's hair-trigger revolver—in an unwavering grip aimed at the man's head. I looked closely at her face and saw, beneath the makeup, the thin, hawklike nose and the unmistakable intense gaze of Sherlock Holmes.

The other man swiveled with surprising speed and sprang at Holmes. I pulled my hand loose from my lady companion and in an instant snatched my revolver free of my pocket and fired. Our two shots rang out at almost the same instant, and the man staggered and fell back. The two bullets had both hit above the left eye, and taken away the left half of the cranium.

The women screamed.

The man, with half his head missing, reached out a hand and pulled himself to his feet. He came at Holmes again.

I fired. This time my bullet removed what was left of his head. His jutting windpipe sucked at the air with a low spluttering hiss, and in the gaping neck I thought I saw purplish-white tendrils feeling about. The shot slowed him down for no more than an instant.

Holmes's shot took him in the middle of the chest. I saw the crimson spot appear and saw him rock from the impact, but it seemed to have no

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other effect.

We both fired together, this time lower, aiming for the horror hidden somewhere within the body. The two shots spun the headless thing around. He careened against the cauldron of tar, slipped, and fell down, knocking the cauldron over.

In an instant Holmes was on him.

"Holmes, no!"

For a moment Holmes had the advantage. He pushed the monster forward, into the spreading pool of tar, struggling for a hold. Then the monster rose, dripping tar, and threw Holmes off his back with no more concern than a horse tossing a wayward circus monkey. The monster turned for him.

Holmes reached behind him and grabbed a brand out of the fire. As the monster grabbed him he thrust it forward, into the thing's chest.

The tar ignited with an awful whoosh. The thing clawed at its chest with both hands. Holmes grabbed the cauldron, and with one mighty heave poured the remainder of the tar onto the gaping wound where its head once had been.

Holmes drew back as the flames licked skyward. The thing reeled and staggered in a horrible parody of drunkenness. As the clothes burned away, we could see that where a man's generative organs would have been was a pulsing, wickedly barbed ovipositor with a knife-sharp end writhing blindly in the flames. As we watched it bulged and contracted, and an egg, slick and purple, oozed forth.

The monster tottered, fell over on its back, and then, slowly, the abdomen split open.

"Quickly, Watson! Here!"

Holmes shoved one of the pieces of firewood into my hands, and took another himself. We stationed ourselves at either side of the body.

The horrors which emerged were somewhat like enormous lobsters, or some vermin even more loathsome and articulated. We bludgeoned them as they emerged from the burning body, trying as we could to avoid the oily slime of them from splattering onto our clothes, trying to avoid breathing the awful stench that arose from the smoking carcass. They were tenacious in the extreme, and I think that only the disorientation of the fire and the suddenness of our attack saved our lives. In the end six of the monstrosities crawled out of the body, and six of the monstrosities we killed.

There was nothing remotely human left in the empty shell that had once been a man. Holmes pulled away his skirts and petticoat to feed the fire. The greasy blood of the monstrosities burned with a clear, hot flame, until all that remained were smoldering rags with a few pieces of unidentifiable meat and the charred scraps of bone.

It seemed impossible that our shots and the sounds of our struggle had not brought a hundred citizens with constables out to see what had happened, but the narrow streets so distorted sounds that it was impossible to tell where they had originated, and the thick blanket of fog muffled everything as well as hiding us from curious eyes.

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Holmes and I left the two daughters of joy with what money we had, save for the price of a ride back to Baker Street. This we did, not with an eye toward their silence, as we knew that they would never go to the police with their story, but in the hopes—perhaps foolish—that they might have a respite from their hard trade and a warm roof over their heads during the damp and chill months of winter.

It has been two months now, and the Whitechapel killings have not resumed. Holmes is, as always, calm and unflappable, but I find myself unable to look at a wasp now without having a feeling of horror steal across me.

There are as many questions unanswered as answered. Holmes has offered the opinion that the landing was unintentional, a result of some unimaginable accident in the depths of space, and not the vanguard of some impending colonisation. He bases this conclusion on the fact of the ill-preparedness and hasty improvisation of the being, relying on luck and circumstance rather than planning.

I think that the answers to most of our questions will never be known, but I believe that we have succeeded in stopping the horrors, this time. I can only hope that this was an isolated ship, blown off-course and stranded far from the expected shores in some unexpected tempest of infinite space. I look at the stars now, and shudder. What else might be out there, waiting for us? ■

Biolog continued from p. 115

gineering-tech that this magazine pioneered and has been preeminent in for the past half-century—which coincides with the achievements of the largest number of scientists and engineers ever living at one time.

In a Greg Bennett story, you'll find that teamwork is necessary but an individual's contribution is vital. We can no longer survive without advanced science, given the enormous population density. Along with this, today's most significant literature is science fiction. Greg's experience echoes Fred Pohl's notation that whatever else SF demands, you have to be clear and unambiguous. Having found that his stories' illustrations often differ from his conceptions, Greg now tries to have his descriptions clear-cut. His engineering soul wishes he could send blueprints to the artist. ■

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Neptune Crossing, Jeffrey A. Carver, TOR, $?, ? pp. (ISBN: 0-312-?).
Moving Mars, Greg Bear, TOR, $?, 448 pp. (ISBN: 0-312-85515-X).
Pallas, L. Neil Smith, TOR, $23.95, 435 pp. (ISBN: 0-312-09705-0).
Growing Up Weightless, John M. Ford, Bantam, $11.95 (trade paper), 247 pp. (ISBN: 0-553-37306-4).
The Innkeeper's Song, Peter S. Beagle, ROC, $20, 346 pp. (ISBN: 0-451-45288-7).
Powers That Be, Anne McCaffrey and Elizabeth Ann Scarborough, Ballantine/Del Rey, $20, 313 pp. (ISBN: 0-345-38173-4).
Majyk by Accident, Esther Friesner, Ace, $4.99, 282 pp. (ISBN: 0-441-51376-X).

It's a fact of magazine publishing that columns such as this one must be written months before you see them. This means, among other things, that books I review are often gone from the bookstores well before you know to look for them. This is even true when the publishers send me galleys, for the books are generally scheduled for publication just two or three months later, still several months before my review can appear.

Readers find the situation frustrating, but so do writers, who would love to believe that good reviews can boost their sales, if only those reviews appear while the book is available. They may even be right, but very few writers—Mike Resnick and David Gerrold are two—have taken advantage of the offer I have made before, to look at the manuscript months before the publisher has set type and produced galleys. Perhaps the cost of photocopying and postage puts them off; writing is a lucrative profession for only a few of us.

There *is* another way. A writer can send me his or her manuscript on disk. The only limitation is that the disk be for an MS-DOS computer; my word-processor can read Wordperfect, WordStar, and other files. Jeffrey A. Carver tried this with his last book (*Dragon Rigger*) and liked the results well enough to do it again.

Carver's **Neptune Crossing**, the first volume of "The Chaos Chronicles," is scheduled for April 1994, and I think it will move off the bookstore shelves pretty briskly. It is set on Neptune's moon, Triton, which is laced with strange, once-molten

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alloys, the remnants of some ancient civilization. Unbeknownst to the miners busily extracting the treasure, an alien device, the "translator," is also buried beneath the ice.

The mining operation, run by obnoxious bureaucrats, includes a nominal few "exoarcheologists," but it is John Bandicut, a pilot whose ability to connect with computers has been destroyed by incompetent medical treatment, who discovers the alien gizmo. He is now a surveyor, and one day he strays off his planned course, is shanghaied by the translator—apparently because he is a naive chump of a loner—and awakens with an alien, the quarx, resident in his brain. Once the quarx learns how to talk with John, it reveals that it has been teamed with the translator for eons, traveling from world to world, helping sentient species wherever it found them with their problems. And yes, humans have a problem. They don't know it, but the translator has seen hints in the chaotic dynamics of solar system orbits and other phenomena. Get us some information, John, and— Yes! That's it! A comet in your blind spot, scheduled to strike the Earth in forty-seven days! But you can't tell anyone, John. They wouldn't believe you, since the loss of your implants left you prone to silence-fugue. Try to tell them there's an alien in your head who says the end is nigh, and it's white-jacket time for sure. But, together—and please don't pay that cute Julie from exoarch so much attention; ugh, flesh and all that, disgusting!—together, if you can steal a ship, and if the translator's little tricks work the way they're supposed to, and if we can hit that comet head-on. . . . Why, no, John. Of course you won't be coming back to Julie. But there's a slim chance of survival.

Since we know this is the first volume of a series, that slim chance has to pay off, dumping John and quarx on the doorstep of something strange and marvelous and thoroughly enticing. Those who read this one will surely return for a second helping.

The tale's charms include the way the quarx has of dying on the verge of crises, just when Carver wishes to ratchet the tension up another notch. Yet there are also a few aspects to the tale I don't think work so well. For instance, the use of chaos theory, especially the idea that sufficiently advanced mathematics can use it to make the future visible, does push my "Oh, yeah?" button.

But don't let the bafflegab stop you. Carver has a fascinating vehicle here, he's going someplace interesting, and there are still seats available. Grab one.

Greg Bear joins the recent flood of Mars novels with **Moving Mars,** a massive saga that culminates in an escape trick even Houdini could never have pulled off, founded in the idea that the particles that comprise matter are little more than a bundle of "descriptors" that specify each particle's mass, charge, and location in time and space, among other things. "Tweak" one of these descriptors, and you change it. Presto, and you've got antimatter, anywhere in the uni-

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verse you like. Presto, and you're peeking through a window a zillion light-years away. Presto again, and you're there, in the flesh.

Of course, Bear doesn't begin with the magic. In the year 2171, or Mars Year 53, the Red Planet is past the initial stages of colonization. There are, in fact, universities and a Statist political movement, strongly influenced by Earth, is trying to unify the planet under a firm, paternalistic hand. To stifle dissent, the Statists have just kicked out of one university all students and faculty who arouse the faintest suspicion of potential protest. Not surprisingly, the result is the precise opposite of that intended, and even as the Statists fall, student Casseia Majumdar has had her eyes opened to the potential for tyranny. She becomes a student of politics and management. In due time, she gains the position of assistant to Mars's emissary to Earth and learns a great deal about Terrans—made universally sane by mandatory therapy, fond of bioengineered transformations and computer-implant enhancements (you'll recognize touches from *Queen of Angels*)—and about how deeply the divisions between the two cultures run.

Along the way, she has a youthful fling with Charles Franklin, an ambitious physics student who dreams of learning how to access and manipulate descriptors. Their affair is brief, for Charles's intensity and apparent arrogance put an uncertain Casseia off. Both move on, but their lives will touch again after Casseia has become a core element in a new movement to unify Mars and resist Earth's effort to absorb this new world. She will learn that Charles is making progress toward his dream, and Earth and its minions are showing strong interest. Then, when on the eve of Mars's first planetary elections, Earth attacks with computer viruses and other devices that paralyze Mars's workings, she finds Charles and his colleagues have fled their Earth-minion-controlled labs. They have undreamed-of powers, one of which is enough to prompt a terrified Earth to mount an all-out effort to catch up. There is no possibility of a cold-war balance of terror, for a single blow will soon be able to preempt any possibility of retaliation. Earth's paranoia is a perfectly sane response to the situation, for Earth cannot trust Mars's good intentions.

With what I've said and with the novel's title, you can surely see where Bear is going. He almost makes that destination believable, partly because he does such a grand job of establishing credibility for a Mars with fossils, a society built on Binding Multiples (leagues of families, something like a Heinleinian line marriage), realistic politics, and sympathetic characters.

Many of this novel's best features are concentrated in its first half. The second half feels too much like a recital of milestones on the way to the wonder of the conclusion; it's practically pedestrian. Yet perhaps this will not interfere too greatly with your enjoyment; that first half does establish a great deal of momentum.

It's not really fair to pigeonhole an

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author according to his or her politics, for good authors routinely write beyond the boundaries of their belief systems. Yet it can be appropriate to mention those politics, particularly when they so pervade a work (or a career) as to turn the author into a pamphleteer.

L. Neil Smith is a Libertarian author. Indeed, he won the Prometheus Award for Best Libertarian Novel for his 1981 *The Probability Broach,* and later work has been in the same vein, stressing individual freedoms and responsibilities while calling those who emphasize individual rights something close to social parasites.

There's a good deal in such a view to agree with, especially when society seems to have tipped a bit too far toward rights at the expense of responsibilities. Unfortunately, Smith simplifies the issues to the point of ridiculousness, posing heroic manly men and womanly women, armed with handguns—anyone who gets shot must have had it coming, you know?—and supporting themselves by hunting, against villainous socialist slave-driving sex-fiend bureaucrats.

I simplify a bit myself, of course. The novel at hand is **Pallas,** set on the asteroid of the same name, its rugged terrain now covered by an atmosphere-retaining plastic bag, seeded with plentiful vegetation and game, and peopled by rugged individuals whose basic principle of government is one-man, one-veto. Justice is dispensed by Aloysius Brodie from the local saloon. The echoes of Wild West mythology are quite deliberate.

One of Pallas's larger craters has been taken over by the UN as the site of an experiment in communal agriculture. The bureaucrat in charge, ex-Senator Gibson Altman, was banished from Earth for videotaped offenses against decency. He and his cattle-prod equipped goons, otherwise known as "Education and Morale Counselors," keep the peasants brutally in line. But one of those peasants, Emerson Ngu, dreams of escape to the Outside, where respect for the individual means freedom to be more than a slave to a paternalistic Big Daddy.

He does escape, of course, and he soon prospers, using his mechanical talents to invent and market an affordable handgun, cheap personal transportation, and so on, all in service to individual freedom. He soon loses his girlfriend to Altman's vicious, beady-eyed son, and when she returns for a visit, he loses her for good—and almost himself as well—to goon assassins. He survives, prospers, becomes filthy rich, and earns the undying hatred of Altman. Yet the villain is doomed to see his empire wither since people really don't like to be penned up, ordered around, and protected "for their own good." They'd rather take a few risks in the hope of striking it rich.

The story has all the drama—or melodrama—you could wish for, especially if you're a fan of TV soap operas. If the action were a little faster, the simplification and reliance on straw men would not really be much of a problem. Sadly, the novel's political baggage is so weighty that it bogs the story down in a morass of lec-

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tures, diatribes, and pseudophilosophical justifications. Nor does it help that Smith tosses in sudden climatic shifts and new technologies with more regard for where he wants to take the story than for plausibility.

If you're not a Libertarian, Smith will not convince you. If you are, you'll love *Pallas*. It's your choir Smith is preaching to.

John M. Ford has quite remarkably captured the spirit of adolescence on the verge of flight in **Growing Up Weightless.** It hardly matters that the setting is an independent Luna whose people sneer at the visiting "Slammers," whose movements lack the grace of those accustomed to low gravity. Yet I am not at all suggesting that Ford's novel is not in its heart and soul science fiction. This is not a "horse opera" whose horses have been replaced with spaceships, but a statement of the universality of the human life cycle, and quite an effective, cogent statement at that. It is also a very satisfying novel.

The central adolescent is Matt Ronay, a brilliant youth who runs with a group of equally brilliant friends. He has a number of talents, one of which—theater—offers him a challenging niche that nevertheless falls short of his dreams of boarding a starship and escaping to other worlds. His father—referred to as He and Him as if he were a veritable god (and what else are parents to their children?)—is a forbidding figure, once a composer of note, now a dominant player in Lunar politics. His mother, a surgeon, is a somewhat more distant figure; it is the father against whom the son holds himself, always expecting to fall short, at least in the father's eyes.

Ford provides a tour of a Lunar society and technology that feel quite real as he shows us Matt and his friends and their plan to escape for a few days on a journey to a distant city. They engage in virtual-reality role-playing games, but the journey will be their first test flight in the world of adults. Matt is offered two temptations, one to a life of routine, one to a life of continued play-acting, of tinsel glamor. He accepts the latter, but later, when play-acting turns urgently real and the opportunity arises to grasp for the real thing. . . .

His father, whom Matt sees as never understanding, never having yearned, never having faced similar temptations, watches, recognizes the brilliance of Matt and his friends, and remembers his own youth. There are hints that the bureaucrats who rule the Moon and indeed achieved its independence were once a clique much like Matt's. There is more than a hint that the yearning remains, burning as bright as ever, even when one's fledgling has spread his wings and taken flight.

This is one that could claim major awards. Don't miss it.

Peter S. Beagle is well known for beautifully crafted fantasies—think of *The Last Unicorn* and *The Folk of the Air*—that offer rather different takes on familiar themes. It is thus a great pleasure to find that he has produced a new novel, **The Innkeeper's Song.**

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Beagle's numerous fans undoubtedly grabbed the book as soon as they saw it on the bookstore shelf. For those of you who resisted temptation but have been wondering whether those who succumbed got their money's worth, let me assure you they did.

The tale is constructed as if, many years later, its several characters are relating what happened to an interviewer, perhaps the novelist, perhaps the reader, perhaps just a stranger who has joined them at their table in the inn. Why are they talking? Well, perhaps someone sang the title song—

"There came three ladies at sundown:

one was as brown as bread is brown,

one was black, with a sailor's sway,

and one was pale as the moon by day."

—And they hinted that they were the ladies, the innkeeper, the potboy, the stableboy, or even the fox. The interviewer said, "Mmm?" and they answered, "Buy me a drink, and I'll tell you. . . ."

The prologue sets up the situation: Two lovers, soon to be married, are strolling. They pause on the village bridge, where winter rains have rotted a railing that gives way. The bride-to-be, Lukassa, drowns. The groom-to-be, Tikat, tries to save her but fails, and then neither he nor his fellow villagers can find Lucassa's body. Yet that night, while he sits forlornly on the bank, a strange woman appears, says a few words, and raises Lukassa from her watery grave. Sadly, she ignores her bereft lover, turning and leaving with the stranger. Tikat, of course, follows desperately.

Now the characters begin to speak for themselves. Here is the stableboy, Rosseth, who meets three women—black, brown, white—on their way to the inn, with a fox in a saddlebag. Here is the innkeeper, Karsh, a fat tyrant who is sure his new guests will be the ruin of him. Tikat again, starving in the wilderness until a man in a red coat points the way. The women, black Lal, Sailor Lal, who feels drawn by dreams to the aid of an old friend, a wizard; and Nyateneri, in flight from a strange convent that sends assassins after its apostates and also linked to the wizard.

Once everyone is at the inn, the search for the wizard begins. Alas, he has vanished, and only the recently dead Lukassa can read the signs of struggle with a rival and demons. They learn more—the wizard is doomed, his foe is a one-time student whom no one can defeat even though he is now dead, his fate is one of horror and peril to all the world. Yet when the final confrontation arrives, there proves to be hope after all. One of those at the inn has the power to draw the wizard back from death. Another has the power to draw that one as well. And a third turns out to be a *deus ex machina* in disguise with so much strength one cannot help but wonder why it did not intervene sooner.

Am I too cryptic? Tough. If I am more precise I will surely spoil your fun, for it is in the disguises that Beagle conceals his hand. The innkeeper,

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for instance, is a rather nicer fellow than he seems at first, and his tyranny has a solid foundation in guilt. One of the women is . . . well. And the fox . . . hmmm. I dare not say.

This is the kind of novel that absorbs you. Beagle tells the tale at one remove, but he still convinces you of its reality, and you are so reluctant to let him go at the end that, "Stay!" you cry. "Have another drink! And say, about that fox, what was his history? And what happened after?"

But there's no sequel promised. To his credit, Beagle always leaves you wanting more. I commend him and all his works unto you.

Anne McCaffrey and Elizabeth Ann Scarborough both have the storyteller's gift. McCaffrey's many novels, with their immense reader appeal, have made her one of the most popular authors of SF and fantasy. Scarborough hasn't written as many novels or met such immense success, but she's working on both, and I am sure she too will earn a pinnacle in the pantheon.

Because these two writers produce very different sorts of stories, I thought it interesting that they should collaborate on a trilogy and could not resist reading the first volume, **Powers That Be.** What I found was an enjoyable, absorbing, fast-moving tale that combines SF (an interstellar civilization dominated by high-handed corporations) and fantasy (telepathic pussycats and foxhounds). It begins when Major Yanaba Maddock, her lungs ruined by exposure to poison gas, is retired to Petaybee, a world terraformed from barrenness to arctic frigidity and settled by ethnic groups supposedly suited to the environment (Inuit and Irish). The planet is owned by the Intergal corporation, which made it habitable and used its peopling as an excuse to empty out and seize coveted lands on Earth.

Even though she is supposedly retired on medical disability, Maddock is assigned to investigate anomalies: disappearing mineral survey teams, strange life forms the genetic engineers had never been authorized to develop (including a strange sort of unicorn), and more. When she finds not conspiracies and rebellion but a people with a mystical link to their world, those cats and dogs, a cure for her irreparable lungs, people whom she can like, and even romance, her superiors decide she has joined the conspiracy and turned heavy-handed. Fortunately, the planet itself takes a hand at that point, and everything turns out just fine.

Yes, this one is fast-moving, absorbing, very readable. I enjoyed it. Yet whenever I stopped to think about what I was reading, I balked. I had problems with the economics of a system that could move whole peoples from a small piece of one planet to a whole other world (reservations are generally smaller, hmm? and interstellar transportation has to be quite expensive) while being stingy about basic supplies; corporations whose high-handedness is so arbitrary, irrational, and counter-productive (as well as inconsistent with the character of the one board member

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we meet) that they could not possibly survive in a competitive environment; hereditary professions in a technical civilization; telepathic critters; sentient planets; anachronistic references to today's world that have no context in the story; and a good deal more.

But it's still a good read. I expect the next two volumes will be too.

Another series begins with Esther Friesner's **Majyk by Accident**, a light and frothy confection of puns, wordplay, and just plain unabashed silliness that will surely keep you smiling. Set on the world of Orbis, which changes shape often enough to keep folks confused about the flat vs. round thing, it begins in the castle of Master Wizard Thengor. The wizard is dying, and as is customary, he is about to parcel out his hoard of Majyk (the stuff that gives magic its punch) among his students. Kendar Gangle, known as Ratwhacker because that is his only skill, is the least of those students. Banished to the kitchens, he is crouched by a rat hole when a mythical beast known as a cat comes through from our world. Kendar chases it upstairs and down and through the wizard's chamber just in time to intercept the cloud of released Majyk. Instantly the object of his fellow students'—especially Zoltan Fiendlord's—wrath and envy, he must ward off magical attacks, twig to the fact that the cat is called Scandal, talks sassily, and has a load of advice, and hie off in pursuit of the rest of the Majyk hoard and enough magical competence to save his life. Very quickly, he acquires a barbarian sidekick, a wife who hates life among the telepathic, nectar-sucking Welfs, and a mission to kill a nice-old-lady witch. He finds ways to control his Majyk, displays his kind heart, and escapes disaster after disaster by the skin of his rump. And so on.

If you need a comparison to precedent, call it P. G. Wodehouse on amphetamines. Enjoy. ■

Public opinion, in its raw stage, gushes out in the immemorial form of the mob's fear. It is piped into central factories, and there it is flavored and colored, and put into cans.

H. L. Mencken

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BRASS TACKS

Dear Stan,

In your Sept. 1993 issue Mr. Lloyd Hauger says that author L. Sprague de Camp has an anti-gun attitude. I've been reading Mr. de Camp in the pages of *Astounding* since 1937 and have never noted this tendency.

While writing the Conan series Sprague covered the Hyborian landscape with so many headless bodies that you couldn't step into the street without stumbling over one of them.

I assure Mr. Hauger, that given sufficient provocation, Sprague would tackle a grizzly bear or a street thug with the same enthusiasm. Using a weapon of his choice, like a ten-inch naval gun, hunting rifle, crossbow, or large rock, he would correct the situation.

Then he would apologize to the widow, or mama bear, and offer to pay for the funeral.

HOWARD DEVORE

Dearborn, MI

Dear Stan:

Lester Del Rey's contributions to the art of the printed word, both as writer and publisher, were too extensive to cover in a simple note *in memoriam.*

My own happiest Del Rey memory stems from his treatment of the Norse Armageddon legend, *Day of the Giants,* published during the '50s. The Valkyries are sent for a modern-day Berserker, but instead retrieve his brother, an analytical, no-nonsense engineer.

Inadvertently soul-bonded to one of the Valkyries shortly after arrival, he puts his training and experience to work on the problem. In short order, using a magic mirror to access classified documents, and with the Stone Dwarves' aid in fabricating whatever hardware is needed, he advances the Norse God's nonmagical military capabilities from barely Iron Age weaponry to pocket nukes.

It was in this novel that Lester committed the single most awesome understatement in the history of the printed word: As the Stone Dwarf foreman proudly displayed his first batch of U-239, he warned, "Keeps better in small pieces. . . ."

You'll be missed, Lester.

DAVID R. PALMER

Dear Mr. Schmidt:

I have just finished reading "The Plot to Save Hitler" in the September 1993 *Analog.* I was struck by something that I read on page 48. The author states: "Urbanek had barely had the time to skim Martin's books before he was dispatched into the past by scientists who feared the unknowable consequences

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of delay." Since Urbanek has the use of a time machine, can't he take all the time he wants?

Also, Urbanek knows what Martin is going to do, can't he use his time machine to keep him from going back into time?

MICHAEL K. BUCKLEY
2023 N. 56th St.
Omaha, NE 68104

The author replies. . . .

Dear Stan:

Mr. Buckley raises a couple of good points about writing time-travel stories, but his first question answers itself. Urbanek couldn't take all the time he wanted because the project scientists "feared the unknowable consequences of delay." I could have injected a lot of arm-waving doubletalk here, but I wasn't writing a story about paradoxes and the mechanics of time travel; I was writing about a moral question. Besides, time-travel is at best a vague theoretical possibility, and anything I could write about its workings would most likely be wrong and silly in equal measures.

Why didn't Urbanek just go back in time a few days to stop Martin? Again, I could have held up the story with doubletalk about avoiding paradoxes, and the obvious fact that Urbanek hadn't shown up at the Chronlab a few days ago to prevent Martin's departure, but the truth is simpler. If Urbanek had done that, there would have been no story—and at seven cents per word, I'm too crafty for that.

BILL THOMPSON

Dear Sir:

I enjoyed Mr. Lunan's story, "With Time Comes Concord" (Sept. 1993)! It was well written, followed a believable plot, and did not require an immense suspension of belief. Now, how about the "other side" of the story? What happens to the poor accident investigator and county coroner when the bodies from the wreck in the other universe are recovered and found to be frozen to the core and otherwise damaged as described on page 155? Or do we assume that the plane, its passengers, and contents continue as before and the 30 years of storage never existed?

Please send my compliments to Mr. Lunan and tell him to feel free to take the above and go forth. I would like to read his treatment of the opposite numbers in the other universe dealing with the crash.

C. HENRY DEPEW
Tallahasse, FL

The author replies. . . .

Dear Mr. Depew,

I find that time-travel stories (mine, at least!) always involve a paradox of some kind, which may provide an alternative to A.J. Ayer's attempted demonstration of the illogicality of time travel. In this case, the area I had to skirt was that the other universe is supposedly identical to ours, except for the name of the aircraft; yet Pendleton's life has been very different, and the fictitious hangar T-50 would have been demolished or used for something else. . . . In the first draft p. 157, I originally wrote "on his counterpart's desk, the telephone would ring." But that could imply that Pendleton was in the same job, in the other universe, although his career path to it would have been quite different—so I'd be getting letters about that too, unless

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I specified that the two universes converge again. . . .

But if the other universe converges with ours, then the aircraft would be destroyed in both, and Pendleton's 30-year effort would be for nothing, which wouldn't make much of a story. If it doesn't, then the most obvious way for it to differ would be for the girl not to exist in our Universe, because of the different life Pendleton has led. That would have taken out the scene in the airport lounge, and made the whole thing much more sentimental—again, not the story I wanted to write.

So we're left with the paradoxes you've pointed out. Now, it could be that supersonic airstream damage conceals all the evidence of the '60s investigation. Or if only the bodies were affected, probably they would have thawed out, and any weird post-mortem results wouldn't be believed, like the soothsayers in *Julius Caesar* who "could not find a heart within the beast." It could end up as a small item in the *Fortean Times*. But I doubt if that would be all. The debris tracing wouldn't make sense, and the wreckage would have two sets of impact damage. There *could* be another story in that. But otherwise, yes, you'd have to suppose that when the wreckage disappears from our Universe its clock jumps back 30 years, back to that vital moment on which air accident investigation concentrates: the last instant at which the aircraft was still in one piece.

Anyway, I'm very glad you liked it!

DUNCAN LUNAN

P.S. It might interest you that I see this story as making a trilogy (time-travel by land, sea and air), with "The Day and the Hour" (in *There Will be War* vol. V, ed. J.E. Pournelle, Tor, 1986) and "In the Arctic, Out of Time" (*Isaac Asimov's Science Fiction Magazine*, July 1989.)

Dear Stan:

Remember the article about the Delta Clipper in *Analog* a couple of months ago? Remember the rumor that Pete Conrad wanted to be part of the 500-pound payload of the DC-X?

I asked Dr. Gaubatz about it at the International Space Development Conference in Huntsville three weeks ago. He laughed and said, "Yes, it's true—but he'll have to beat me out for the honor!" Several of us teased him back, saying, "You two weigh less than 500 pounds combined. You could both go up. One could handle the video camera and the other could fly the bird."

Since the conference committee members for the '94 ISDC in Toronto were also present, this idea became a dream of getting 50,000 space activists into the Toronto stadium, rolling back the Skydome, and having the Delta Clipper come in for a landing on first base with Dr. Gaubatz aboard. You heard it here first!

The whole reason I went to the conference was to present my SSTO Project. The following paragraphs are the gist of a letter I have sent to *Ad Astra* and *Final Frontier*.

As a long-time space activist (my roots go back to the old L-5 Society), I have been watching the hand-wringing about the future of space exploration, development, and settlement with more than a little dismay.

I don't agree that the future for space

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development is gloomy at all. As I see it, the only real problem is that no one's quite figured out how to reveal the potentially huge market for cheap space access. Maybe this is because there didn't seem to be any form of cheap space access that was believable, until now.

But Dr. Gaubatz, program manager for the Delta Clipper, told me at the International Space Development Conference in May that he expects Delta Clipper to go commercial by 2001.

With the DC-X undergoing flight tests this summer, and the possibility of commercial flights within ten years at $10 million per flight ($500 per pound to orbit, a 10-fold drop from the current $5,000 pounds aboard the shuttle), suddenly it's not so unbelievable that ordinary people could be going into space within ten years. Moreover, suborbital transoceanic flights can be expected to cost substantially less per pound. Also, once economies of scale kick in, and competition to produce SSTO-capable vehicles picks up, we can expect the price per pound to orbit as low as $50 per pound within those ten years.

If we could tell people that seat prices for suborbital and/or orbital flights could fall as low as $7,500, will probably average $20,000, and most likely won't exceed $50,000, they might very well start saving up for at least one trip. I know I'd be willing to get a steady job just to sock away that kind of money for a chance to see Earth from space. I'm probably representative of most space activists, enthusiasts, and science fiction fans. That suggests a very large latent market for cheap space access. And that doesn't even touch on the companies who would find it to their advantage to get packages or people anywhere in the world in about an hour, either aboard their own business Clippers or by commercial Clipper.

But, how do we show the skeptics how much we want to go? The key is to create a central clearinghouse—a database similar to the reservation system used by the airlines. I have developed this idea into the SSTO Project which I presented at the Foundry at this year's International Space Development Conference in Huntsville.

What is the SSTO Project? Not the Single Stage To Orbit Project—Dr. Gaubatz and others are hard at work on that one. Try the "Save me a Seat To Orbit" Project. People who are willing to save up for seats (or vehicles) can send their names and addresses, along with (optionally) their desired destination(s) on Earth or off it, to me for inclusion in the database. I, in turn, will track the data and provide quarterly summaries to everyone in the database, *Analog* and other media outlets, and the aerospace companies.

It really is that simple. If your readers are interested in more information about the SSTO Project and how they can participate, they can write to me:

The SSTO Project
c/o Theresa Holmes
614 ½ 21st St.
Greeley, CO 80631

THERESA HOLMES

Dear Dr. Schmidt:

Please excuse the formality, but I have been around long enough so that I feel more comfortable that way. I don't

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remember the month or year of the first *Astounding Science Fiction* magazine that I picked up from the newsstand, but I do remember that it contained the last installment of a serial titled "Slan" by A. E. van Vogt. And that I was thereby hooked on science fiction literature for life. And, while I may not have read *every Astounding/Analog* since then, I have certainly read most of them.

I just received my latest issue a couple of days ago, and as I to began my perusal I realized that I was going about it differently, and had been doing so for several years.

In the earlier years, I would first eagerly read the editorial and then the letters and then the rest of the magazine. I remember particularly the enjoyment of reading the reactions of other readers to the ideas contained in the various stories and articles, and even more so the (sometimes) rebuttals by the authors. The important thing was that I could *remember* from the time that the stories appeared to the time that the readers' comments appeared.

However, as I looked over the letters pages of this latest issue, my reaction was WHAAAAAA! I could not remember any of the stories that the letter writers were referring to! And had not been able to for at least several years. And as a result had put off reading the letters section to last, or sometimes never. *And* had missed a large portion of the enjoyment your magazine has brought to me over the years.

Now I realize that my never very good memory has probably deteriorated over the years, but I think that a comparison of the cover date (August, 1993) to the story dates (December, 1992) also points to a part of the remembrance problem. *Lead times!* Why, Oh Why, must it take *eight months* to get an issue published! With all of the marvelous new technologies applicable to the publishing business, it would seem that lead times should be shrinking, not growing. Maybe the technology is not working so well? Or is not being applied so well?!

To be fair about it, this seems to be the situation with all of the monthly publications that I subscribe to, so you are not alone. Gosh, are you all printed by the same print shop?

I don't have a solution to the problem of long lead times, and I know that they cause many more headaches for you than readers with poor memories, but I bet if enough of your readers put their mind to it, a fix could be ginned up! What about it, do any other of your readers have this problem? Do they have any solutions? Do you want to find out?

Although it may sound trivial to you, it is important to me.

RICHARD E. MEEKER

PSC 01 Box 5281

APO AA 34001

Part of the problem is that science fiction magazines have smaller audiences and smaller budgets than the big slicks, and if you want fast production, it costs extra. Another part is that it takes a while for reader responses to trickle in. In any case, we're certainly interested in concrete, workable suggestions for how to speed up the dialogue! ■

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UPCOMING EVENTS Anthony Lewis

1-3 April
BALTICON 28 (Baltimore SF conference) at Hyatt Regency at the Inner Harbor. Baltimore, Md. Guest of Honor—Mercedes Lackey; Artist Guest of Honor—Larry Dixon; Special Guest appearance—Frederik Pohl; Filk Guest of Honor—Duane Elms; Fan Guest of Honor—Sue Wheeler. Registration—$30 until 28 February, $40 at the door. Info: Balticon 28, Box 686, Baltimore MD 21203-0686.

1-3 April
MINICON XXIX (Minneapolis area SF conference) at Radisson Hotel South, Bloomington, Minn. Author Guest of Honor—Jack Williamson; Fan Guest of Honor—Rusty Hevelin; Publisher Guest of Honor—Tom Doherty. Registration—$22 until 20 February; $55 at the door. Info: minicon XXIX, Box 8297, Lake Street Station, Minneapolis MN 55408-8297.

8-10 April
MISCON 9 (Montana SF conference) at Village Red Lion, Missoula, Mont. Author Guest of Honor—Roger Zelazny; Artist Guests of Honor—Frank Kelly Freas and Lauria Brodian Kelly-Freas; MIRV—Ru Emerson. Registration—$20 until 1 April; $25 thereafter. Info: Miscon 9. Box 9363. Missoula MT 59807. (406) 728-9423.

1-5 September
CONADIAN (52nd World Science Fiction Convention) at Convention Centre, Winnipeg, Manitoba. Guest of Honour—Anne McCaffrey; Artist Guest of Honour—George Barr; Fan Guest of Honour—Robert Runté; TM—Barry Longyear. Registration—$95 (C$125) until 31 December 1993; Supporting—$25 (C$30). This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Join now and get to nominate and vote for the Hugo Awards and the John W. Campbell Award for Best New Writer. Info: Conadian, Box 2430, Winnipeg MB R3C 4A7 Canada or Box 7111, Fargo ND 58109 (204) 942-9494; FAX (204) 942-3427.

You can send me e-mail about your convention—A.LEWIS20 on the GEnie™ network. When calling conventions for information—do not call collect and do not call too late in the evening. ■

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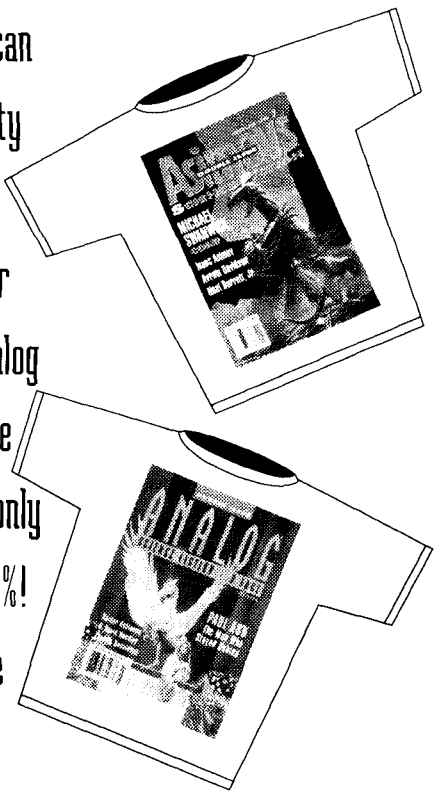

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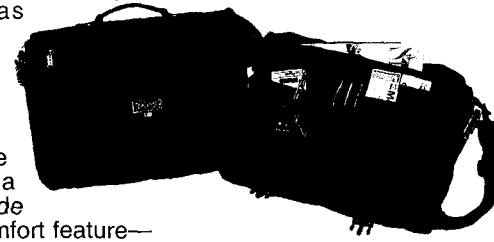

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